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APPLIED MECHANICS REVIEWS

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PRESTRESSING

WACLAW OLSZAK

INSTITUTE OF TECHNOLOGY, WARSAW, POLAND

1 BASIC REMARKS

1 The scope of application of prestressed structures is continuously increasing. The experience of the past ten years has proved that, in many branches of structural engineering, the principle of introducing artificial initial forces into structures may, in many cases, result in technically and economically revolutionary solutions.

The principle of prestressing is given emphasis because, regardless of what kind of structure is involved (e.g., prestressed reservoirs, bent beams, pressure pipes, water dams, tunnel lining, etc.), the *basic idea* always remains the same; viz., the creation of initial internal forces which act *permanently*, are *strictly determined in advance*, and have *precisely defined* consequences.

On the contrary, the means of realizing this general principle may often differ entirely; in fact, there is great liberty in choosing adequate technical means for achieving this purpose and in selecting the basic structural scheme for the solution of a given problem.

2 Prestressed structures constitute a considerable step toward the "static synthesis" dreamed of by scientific innovators as early as the beginning of the twentieth century.

In fact, the designer abandons his passive attitude of obediently approving of the starting "classic" premise which accepts the initial state of the structure as being free from interior forces; he deliberately passes to an active attitude, choosing—in a wide range—the forces that have to act on the designed structure, and regulating their intensity and internal flow according to his own concept (C1).[1]

Initial prestressing of structures means equipping them with surplus potential energy. This supply should always be sufficiently large so that it will not be affected by losses which occur in the course of time. These losses are either irreversible (e.g., losses caused by permanent deformations of concrete and steel) or of a temporary nature (e.g., periodical deformations caused by temperature and hygroscopic changes).

In prestressed concrete, the strain energy of concrete is used for this purpose and, especially, the still much greater strain energy of steel bars.

3 Prestressing permits taking full advantage of the so-called "brittle" materials, such as concrete, natural stone, ceramics, etc., which are available in practically unlimited quantities and are cheap, contrary to the so-called "ductile" materials such as the majority of metals, including steel, which are scarce and expensive.

While the possibility of using brittle materials is extremely varied, concrete still represents the basic material for the overwhelming majority of all prestressed structures; therefore, these remarks will refer chiefly to it.

With regard to bent elements made of brittle materials, the essence of prestressing consists in creating a state of permanent compression in those parts of the structure where, under the action of external loads, tensile stresses would appear. If this state is sufficiently intense and properly distributed, tensile stresses will be entirely eliminated (or reduced to such values as not to affect the elastic behavior of the structure, and with complete elimination of the danger of cracks).[2]

Especially advantageous are two- and three-dimensional states of prestress.[3]

4 The historical development of prestressing is quite different from that of reinforced concrete. Reinforced concrete was born about a hundred years ago from empiricism and experience, and its theoretical foundations were successfully worked out as its development progressed; its first tolerably complete theory was not formulated until about 50 years after its first practical applications.

Prestressing, on the contrary, was born from the principles of applied mechanics and found its scientific formulation first, and only later were means and ways sought to introduce this idea into practice; here, chiefly, lie the difficulties to be overcome (F6f, K7, O2e, P2a).

5 The principle underlying the concept and the design of prestressed structures is not an extrapolation of the idea of reinforced concrete; it is more general (and may be different).

As a matter of fact, the practical execution of prestressing is not bound to the use of "reinforcing" steel bars. A great number of structures have been put into the required prestress without one ounce of reinforcing steel, the initial predeformation being obtained by the application of some external force; e.g., by the use of flat presses (Freyssinet) or of expanding cement acting against fixed abutments.

If, however, steel bars are used, they may be put outside as well as inside the structure. They are "ties" first, and only afterward "reinforcement."

[1] Numbers in parentheses indicate References at end of paper.

[2] Such a definition does not entirely exhaust the principle of prestressing, which is more general; for its exact definition, cf. (F6c) and (O2e).

[3] Recent experiments have proved that, with lateral pressure of 1760 kg/cm², quite ordinary concrete may be loaded up to 6100 kg/cm² (C8, M9c).

On the other hand, prestressed structures exist whose execution does not necessitate the use of any concrete; e.g., structures in prestressed natural stone (A2, F2, F4), prestressed ceramics (B6, D5), glass prestressed by thermal processes, plastics, even foundation soils (F6c,f).

Also quite different from reinforced concrete is the behavior of prestressed structures in their statical action. In reinforced concrete, the couple of interior elastic forces equivalent to the bending moment of the external load is based on the concrete-steel association. In prestressed structures, this internal mechanism is based on the fully acting couple concrete-concrete or, if other prestressed materials are used, on the couple stone-stone, glass-glass, etc. (F6f, P3, O2d).

6 The chief advantages of prestressed structures are:

(a) The possibility of using artificial interior forces allows for the compensation of a great portion of exterior loads (mostly the whole of the permanent load which may attain 50 per cent and more of the whole loading) without increasing the quantities of concrete and steel used (variation of cable eccentricity is sufficient); even the effects of moving loads may be cut down to oscillations of 50 per cent (G7b).

(b) The concrete acts with its complete section; consequently, improvement of its quality fully raises the bearing capacity of the structure and its stiffness (G8).

(c) Cracks can be eliminated; hence, high quality of products unattainable in reinforced concrete are possible (e.g., compactness, elastic deformability); elimination of oblique principal stresses can be obtained; hence, high impact strength (P2a).

(d) There is the possibility of using (contrary to reinforced concrete) materials of high and highest quality; hence, economy of steel up to 80 per cent and more in weight, in concrete up to 30 per cent.

(e) New technical possibilities include slenderness of structures, increased spans, putting together of blocks, assembly by prestress, etc.

II MECHANICAL PROPERTIES OF MATERIALS

Theory and practice of prestressed structures are essentially affected by the mechanical properties of the materials employed.

1 As a rule, materials of highest possible strength are used, so that the losses referred to above are maintained on the lowest (both absolute and relative) level possible. For similar reasons, very intense states of stress are used, which also allow for great economy in the consumption of materials.

On the other hand, in addition to elastic deformations, irreversible ones appear in the material; moreover, the deformations change in time, which fact necessitates taking into account their *rheological* properties.

2 **Concrete.** The development of prestressing is intimately linked with the development of high quality concrete techniques. As a rule, concrete should have a strength of $R_{28} \geq 500$ kg/cm², low shrinkage, low creep, and high early maturing.

The development of concrete techniques is mainly due to mechanical methods of compacting (mechanical and electro-mechanical vibrators of various amplitudes, variable frequencies from 1000 to 15,000 cpm, high accelerations of the order of 5–10 g and more). Excellent results have been achieved by combining vibration, mechanical pressure compaction, and steam curing. The strength of concrete thus obtained is nearly the same as that of its solid constituents. In model plants, strengths of 1000–1200 kg/cm² were obtained. Safe prestress of such a quality concrete may amount to 500 kg/cm².

3 **Other materials.** Brittle materials hardly suited for beam-type elements seemed apparently to be condemned by the modern development of engineering. Today, because of the possibilities offered by prestressing, the evolution of this group of "*new*" materials (e.g., plastics) as well as the renaissance of "old" ones (e.g., natural stone, ceramics, etc.) is no longer doubtful.

4 **Steel.** Contrary to reinforced concrete where the steel stress is not allowed to *exceed* a certain limit, so as not to evoke the danger of serious cracking, in prestressed structures it is not advisable to use steel *below* a certain quality limit.

The tensile strength of steel used today, depending on its chemical composition and the wire diam, is as high as $R_r = 28{,}000$ kg/cm² with the corresponding (conventional) elastic limit of the order of $Q_r = 23{,}000$ kg/cm². In such cases, the working stress may amount to $k_r = 0.7R_r$ or $0.875Q_r$ (as admitted in some codes of practice); in fact, practical designs are based on values k_r = 12,000 to 16,000 kg/cm² and more.

III THEORY

The theory of prestressed structures differs in many points from what has been generally accepted in the current theory of engineering structures.

1 Prestressed structures being equipped with certain interior forces before they enter into their load-carrying action, the state of stresses is no longer a homogeneous function of the forces acting on the structures.

2 The correct theory must take into account not only elasticity of concrete but its viscous flow and its plastic deformations; the phenomenon of "adaptation" is connected with it; with that comes the shrinkage of the hardening cement paste. In steel, besides its elastic response, relaxation under (quasi) constant strain occurs.

To describe these rheological properties the classical concepts are no longer adequate. The theoretical research work involved may be classified into two groups.

3 In the first group the theoretical approach is essentially adapted to practical design purposes. It simplifies as much as possible the complex phenomena and uses, as a rule, experimental data and parameters.

Such simple theories have been worked out by Y. Guyon (G7a), P. L. Pasternak (P2a), G. Magnel (M5c), E. G. Rate and S. E. Freifeld (R2), P. W. Abeles (A1a), M. R. Roš and M. Mischke (R5), V. V. Mikhaylov (M9d), and W. Ołszak (O2a). As a rule, elastic deformations, creep, and shrinkage are taken into account and analyzed separately, and their effects are obtained by simple superposition. The authors are aware of the inherent inexactness of this procedure, as was proved theoretically and experimentally (L15, M5c).

4 Much more complex phenomena are involved, inasmuch as all types of deformations mentioned above, acting simultaneously, mutually influence each other. As a result, e.g., the process of relaxation will be considerably attenuated [cf. experimental verification (M5a, P2a)]. Therefore, general theories have been worked out and solutions for some basic cases established: By G. Colonnetti, states of coaction (C10); A. R. Rzhanitzyn, elastic-viscous systems (R7); N. Ch. Arutyunyan, creep with aging (A3a,b); F. Levi, isomorphic distortions (L9); A. Galli and F. Franciosi, nonlinear viscous flow (G1); W. Olszak and J. Litwiniszyn, three-dimensional creep (O2f); nonlinear rheological models (L15).

Some other authors do not go into the rheological behavior of the materials and content themselves with the nonlinear stress-strain relation up to failure, e.g., V. V. Mikhaylov (M9d), E. Mörsch (M11b), K. Billig (B5b), and S. Hempel (H3c).

These investigations should be carried out and developed. They must constitute the basis for the analysis and design of pre-

stressed structures; besides, they are closely linked with the problem of prestress losses.

5 All types of delayed deformations are accompanied by prestress losses. The problem of these losses is of basic importance to the safety and economy of prestressed structures. These losses should be as low as possible, which in turn calls for the use of the highest quality of materials.

Part of these losses may be caused by technological processes of manufacture; e.g., losses caused by elastic deformations with anchorage by bond. Additional losses enter because of slip in anchorages and losses due to cable friction (in main curved cables and "cap" cables). All these phenomena must be allowed for in calculations. There is still much to learn about these problems.

6 **Limit states** represent a basic problem. In prestressed bent elements we distinguish three such states (F6f, O2e). The first state is determined by the "transformation" (or "warning") load, the second by the "dangerous" load, the third by the ultimate load.

The first step marks the passing of the element from the prestressed state into the nonprestressed one (but still working in an elastic manner); the second state is characterized by the appearance of irreversible deformations (in concrete or steel); the third state is tantamount to failure.

Especially important in practice are the limit states one and three. In prestressed structures the designer has greater possibilities of regulating these limit states than in nonprestressed structures. In the latter he has at his disposal four parameters (section, its moment of inertia, its depth, position of centroid), whereas in prestressed structures he has seven of them (the four mentioned plus the value, eccentricity, and direction of the prestressing force).

So far, there exists no general theory of either of these limit states. But there exist, especially for the evaluation of the ultimate carrying capacity, some particularly useful solutions; e.g., by V. V. Mikhaylov (M9d), EMPA (R4), E. Mörsch (M11b), K. W. Sakhnovskiĭ (S1), and Y. Guyon (G7d).

7 **Safety.** The analysis of the phenomena exhibited by prestressed structures calls for a new concept of safety. This is caused by dropping of both the linear relations and the homogeneous character of the basic equations connecting the components of stress with the external loads.

Certain values of working stresses may give little or no indications of what margin of safety there exists against collapse. The increase of load might thus even mean the increase of safety (e.g., in the first stages after the initial state, on the first loading).

This problem of safety will have to be solved on a probability basis. The first attempts are being made along the general lines indicated by W. Wierzbicki (W5a) who, in 1936, introduced stochastic considerations into problems of strength of materials and defined the factor of safety on an objective basis; since then this idea has been developed in some of his later papers (W5b-g). In general structural engineering, an analogous approach to this problem is being developed in other countries, based on research work of N. S. Streleckiĭ, N. F. Khotyalov, M. Prot, R. Levi, A. R. Rzhanitzyn, V. M. Kieldysh, P. Gábory, E. Torroja, etc.

The philosophy of safety in prestressed structures, hardly touched upon (C3, F6f), necessitates a comprehensive program of both theoretical and experimental research work.

8 **Statical indeterminacy.** Statically indeterminate prestressed structures have a wide range of application (bridges, shell roofs, reservoirs, frameworks, grids, etc.). There exists in this field some theoretical treatment based chiefly on the theory of elasticity, but practically nothing is known about the redistribution of interior forces (especially bending moments) in indeterminate structures in working conditions and before failure, as a consequence of delayed deformations of concrete and steel (viscous flow, plastic yield, shrinkage) (G7d, T1).

Theoretical studies of the variation in cable position and of the "secondary" moments are in progress at present ["concordant" cables which do not evoke hyperstatical effects (G7c), and cables of more or less arbitrary positions (M5c, L4b, V3), etc.], but there are practically no data concerning ultimate loads in indeterminate structures.

To solve these problems theoretically and experimentally, much effort will be needed.

9 **Special problems.** The slender dimensions of prestressed structures drew attention to the problem of their stability. The relevant research work is being carried out theoretically and experimentally. In this connection, reference should be made to the investigations on the stability of compressed elements [G. Magnel (M5c), C. Eimer (E1a,b), H. C. Duyster (D7)], and on lateral stability of bent elements [S. Kaufman (K2a,b)]. These problems call for further elucidation.

The necessity of using immense values of prestressing forces leads to dealing with the effects of intense stress concentrations in the neighborhood of the anchorages. The introductory research work (M5c, G7d, C6) should be extended.

The problem of dynamic loads, except for a few tests, has hardly been touched upon.

IV PRACTICE

Up to now practice has shown four basic trends of development in prestressed structures, which, in the present stage of evolution, clearly lead to distinct specializations: 1 mass production in great series; 2 great engineering structures; 3 special structures; and 4 structures built of materials other than concrete.

It is interesting to note that, in some countries, methods of group 1 have been highly developed; in others, those of group 2.

The methods for group 1 are based mainly on prestressing by bond. Industrial methods were mainly developed in three types: long-line systems (70–100 and more m) with fixed forms; long-line systems with gliding forms; and individual forms. An original method of automatic individual production has been worked out by V. V. Mikhaylov (M9c).

The afore-mentioned processes are suitable for mass production. Standard elements are the main object of manufacture, such as floor joists, roof beams, floor and roof slabs, railway sleepers, foundation piles, transmission lines and telegraph poles, pipes, hollow elements, etc.

In the field of great engineering structures the merits of prestressing are still more manifest than in group 1. During the past ten years a large number of impressive structures have been conceived and erected (several known leading achievements by E. Freyssinet and G. Magnel). It would border on the impossible to enumerate all of them; therefore, for illustration, only a few examples will be given.

In bridge engineering, mention should made of very slender and very flat two-hinged arch bridges at Esbly, Ussy, etc., 74 m; continuous two-span bridge at Sclayn, 2×63 m; and the bridge at Worms, $104 + 114 + 101$ m.

Other interesting structures worth mentioning are: airplane hangars (Melsbroek) with a free space 40 m $\times$ 115 m; shell structures (G9); reservoirs of 30,000-m³ capacity; airfield runways for planes of heaviest types (wheel pressure 80 t); road constructions; industrial structures; underground garages; hydraulic structures; quays and piers; warehouses; pylons; galleries; tunnels; pits; etc.

Thin-walled shell structures are gaining an ever-increasing scope of application; prestressing allows for improvement of the

boundary conditions and elimination of the parasitic bending moments so as to approach the membrane state with the material fully utilized.

There are numerous instances of difficult structural problems, the solution of which without prestressing would be very expensive or sometimes even impossible. As examples are the raising of the crown of a water dam by 7 m (Cheurfras), the use of expanding cements for underground structures (Metro), laboratory press for 10,000 t (Paris), foundation caissons for quays, industrial presses, floating docks, barges, etc.

It is worth mentioning that prestressed-concrete ties require less steel than steel ties of the same capacity, being at the same time three times less deformable (O2e).

Investigations on bound columns with pretensioned spirals proved that the changeover from the passive (A. Considéré) to the active attitude (M9c, O2b) leads to very advantageous results; prestressed columns can carry nearly as much as steel columns, with their weight being only one third of the weight of steel columns.

For the fourth group, excellent solutions were obtained in ceramics (floor, beams, and slabs), in natural stone (girders and beams (A2), facade of a bank in Brussels), and in glass, etc. [cf. also sect. II 3].

Glass deserves special attention; it shows another aspect of the problem; thin-drawn glass fibers have a much higher ultimate strength than steel and are at the same time much lighter. Attempts are made to use them as an active means of prestressing.

V FUTURE TRENDS

It is difficult to forecast the line of development of such a fertile idea as prestressing; however, on the basis of the development observed hitherto and of the current work, certain probable outlines already shape themselves.

1 Prestressing has already overstepped the domain of brittle materials and partially passed to structures made of ductile materials as, for instance, steel (M5f), to surface hardening by superficial prestressing (L14, P7, –1), funiculars (G5, –2), improvement of stability conditions (S5), ball bearings (J2), suspension bridges (F1), manufacture of springs (S4), railway equipment (O3), and cast-iron elements (L7, P5).

However, the main trend of development will probably aim at applying prestressing for mass production and, especially, for great engineering structures.

The longest bridge span of today (about 110 m) is only the first stage of development. Freyssinet is of the opinion that prestressed concrete bridges may reach spans up to 600 m and more (F6c). Similar development may be expected in the domain of other great engineering structures.

2 Efforts of leading personalities indicate that simplifications of building techniques may be expected. This in turn would cut down the costs, which at present are still high.

For instance, there is a move toward applying small prefabricated blocks, assembled on the site by simple flat joints, only by prestress. The afore-mentioned bridges in Esbly, etc., represent the prototypes (L1).

3 Transfer of the prestressing process from the site to the factory is exemplified by the manufacture of factory prestressed ties [H. Schorer (S2), H. Chalos (C7). Thermal and electrothermal processes were initiated by B. Ruml (A1a) and K. P. Billner (B4)].

4 Development of prestressing methods by the nature of the building process itself is exemplified by the temporary filling of tanks with heavy liquids; by denivelation of bridge slabs and their successive lowerings onto the bearings, whereby the slab automatically enters into the required prestress.

5 The trend toward automatization of manufacturing processes is very clear. Characteristic is the method of uninterrupted reinforcement [V. V. Mikhaylov (M9c)].

6 The efforts of technologists aim at improving the quality of materials used; e.g., crushing strengths of concrete sought are 1400 kg/cm² (C9); there is a tendency to apply quick-hardening cements; in metallurgy, noncreeping steels, or at least steels with a high (absolute) creep limit, are being searched for.

7 The creation of expanding cements (H. Lossier) with controlled and regulated volumetric expansion forecasts automatic prestressing without any mechanical processes ("autoprestressing"). The possibility of creating not only linear but also two- and three-dimensional prestresses would be very valuable. Conjunction with mechanical forms of prestressing is possible ["integral prestressing" (L16e)].

8 The starting of the production of colloidal emulsions of high viscosity, nonmixing with water, will allow for the creation of great prestressing forces, especially for tunnel, pit, and gallery linings, etc.

VI FINAL REMARKS

1 The future development of prestressing depends essentially on the intensity and the results of research work which is being carried on in all interested centers. To enumerate all the topics being worked on at present would surpass the limits of a short survey article. In view of the expected development, the following topics seem to deserve special attention and call for further exhaustive investigations:

In the field of theory: viscous flow, delayed elasticity, variation of modulus of elasticity in time, creep, and shrinkage, and their influence on the properties of prestressed structures; nonlinear stress-strain characteristics; analysis of two- and three-dimensional stress systems to determine creep prestress losses; lateral instability of prestressed members; resistance to torsion.

In the field of properties of materials: physics of concrete; its nonelastic and rheological behavior; quality control; nondestructive testing methods; metallurgy of high-tensile wires and the effect of cold working; stress-strain-time relationship of various steels; "new" materials (especially their rheological properties).

In the field of co-operation of concrete and steel: stress transfer; losses of prestress due to cable friction, wire slip in the different anchorage systems; creep and shrinkage in concrete and steel.

In the field of properties of structures: mechanism of failure; fatigue and repeated loading; impact strength; statical indeterminacy; safety factors on the basis of statistical research; long-term behavior of existing prestressed structures; range of application in structural engineering; resistance to natural phenomena, especially when exposed to fire.

Methodical scientific research is needed and efforts must be made to bring the principle of prestressing into further practical realizations.

2 Literature on prestressing, in spite of the novelty of the problem, is already very rich but, scattered in scientific and technical journals all over the world, it is rather difficult to get at. The bibliography prepared in 1951 by the Institution of Civil Engineers lists about 700 entries. It is very useful but rather one-sided. Hardly a mention is made of research work in Poland, USSR, Czechoslovakia, Hungary. According to the writer's notes, the present bibliography comprises over 1500 major papers and it increases at a rate of about 20 per month.

Besides current publications and building reports published in periodicals, there are about 20 books dealing with smaller or larger sections of the problem of theory and practice of prestressing. Attached is the list of their authors (without claim of being complete), arranged roughly in chronological order:

E. Freyssinet (F6a); E. Hoyer (H4); E. Mörsch (M11a); K. Billig (B6c); M. J. Devroy (D1); P. L. Pasternak and co-workers (P2a); M. Ritter and P. Lardy (R3) with translation into French; A. P. Korovkin (K7a); M. Roš and M. R. Roš (R4); V. Weinberg and W. Kravtzoff (W4); G. Magnel (M5c) with translation into English; A. A. Gvozdjev, V. V. Mikhaylov, and co-workers (G8); K. V. Mikhaylov (M8); P. W. Abeles (A1a); R. Lichtner and E. Jung (L13); G. F. Thomas (T1a); B. W. Jakubovskiĭ (J1); J. Barets (B4); L. Pacholik (P1); F. Levi and G. Pizzetti (L9); E. Torroja and A. Paez (T2); Y. Guyon (G7d) with translation into English; A. S. G. Bruggeling (B10); A. E. Komendant (K5); G. Neumann (N2); C. Cestelli Guidi (C5); J. K. Tyszowiecki and Z. Bychawski (T3); B. F. Goryunov (G3); W. Olszak (O2e).

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PLANCK, M., Vorlesungen über Thermodynamik, 10th ed. (rev. and enlarged by v. Laue, M.), Berlin, Walter de Gruyter & Co., 1954, xiv + 306 pp. DM 22.

RIDENOUR, L. N., edited by, Modern physics for the engineer, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, xi + 499 pp. $7.50.

ROSENHEAD, L., BICKLEY, W. G., JONES, C. W., NICHOLSON, L. F., PEARCEY, H. H., THORNHILL, C. K., AND TOMLINSON, R. C., A selection of tables for use in calculations of compressible airflow, Oxford, Clarendon Press, 1954, x + 115 pp. 84 s.

SEARS, W. R., editor, General theory of high speed aerodynamics. (High Speed Aerodynamics and Jet Propulsion, vol. VI), Princeton, N. J., Princeton Univ. Press, 1954, xiv + 758 pp. $15.

STÜSSI, F., Baustatik. II, Basel, Verlag Birkhauser, 1954, 313 pp., 217 figs. SFr. 33.30

UDIN, H., FUNK, E. R., AND WULFF, J., Welding for engineers, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, ix + 430 pp. $7.50.

WILLIS, J., Deep drawing, London, Butterworths Scientific Publications, 1954, x + 134 pp. 25 s.

Letters to the Editor

1. Re AMR 6, Rev. 3651 (December 1953): M. S. Frenkel, Formulation of "stability-equations" and the derivations of new constructions, with complete systems of design-formulae, for variable-speed control mechanism.

The review omits to mention that the mathematical formulation of stability in a series of "stability-equations" serves as general "framework" to solve problems in different fields of physics and engineering, as appreciated by the contributors and shown, e.g., in the treatment of control mechanisms, electronics (pp. 334–337), uniform performance of units (p. 338), etc. (Re nuclear physics, see App. VI.)

1 The "framework," as a certain combination of functional forms, is common to all the fields, while the functions substituted into it specify the respective fields.

2 The framework derives new equations characterizing a field; e.g., the conventional differential equation of governing (unchanged since Maxwell, 1868) is shown to lack important terms (p. 322), as confirmed by Dr. R. Oldenburger (Chairman, 1953 International Frequency-Response Symposium of the ASME) (p. 332).

3 The framework yields systems of design equations of ascending order for resolving any unknowns and provides constructions purely mathematically; e.g., for variable-speed control mechanisms, general equations are transformed (pp. 323–324) into a form (eq. 60, p. 325) providing basic constructions (one guide-curve) (pp. 326–327), from which classes of constructions are derived up to the simplest one for any high "degree of precision" (pp. 328–329), with only two guide-curves for components adjustable with one actuating motion (p. 333). This classification shows the shortcomings of conventional constructions (p. 325). The new constructions are designed from simple graphs. M. Frenkel, England

Theoretical and Experimental Methods

(See also Revs. 25, 27, 45, 47, 49, 50, 51, 52, 53, 103, 139, 167, 179, 240, 246, 249, 251, 294, 310)

2. Purday, H. F. P., Linear equations in applied mechanics, Edinburgh-London, Oliver and Boyd; New York, Interscience Publishers, Inc., 1954, xiv + 240 pp. $3.50.

The object of this book is to help readers with an elementary knowledge of calculus to become acquainted with the easier aspects of linear algebraic equations, difference equations, ordinary and partial differential equations, and integral equations, as well as the associated ideas of matrixes, determinants, invariants, vectors, tensors, conjugate functions, orthogonal functions, series, etc. (author's preface). The theory is illustrated by applications to continuous beams, oscillators, heat flow, elasticity, hydrodynamics, vibrations of strings, and membranes. The book is particularly suited to engineers, a feeling of reality being maintained by numerous solutions worked out in detail. The inclusion of a chapter on linear integral equations, applied to continuous beams, is a novel and useful feature in a book of this character. J. L. Synge, Ireland

3. Ahlfors, L. V., Complex analysis, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1953, xi + 247 pp. $5.

The text under review gives, roughly, the material covered in a first-year graduate course on complex variable theory. Proceeding gradually from an elementary discussion of complex numbers, the author builds his structure by considering linear transformations, complex functions, complex integration, infinite sequences, the Dirichlet problem, and multiple-valued functions. Exercises are given throughout the text.

This book is clearly and concisely written by an authority in the field. E. J. Scott, USA

4. Narasimhan, R., On the asymptotic stability of solutions of parabolic differential equations, *J. rational Mech. Analysis* **3,** 3, 303–313, May 1954.

Consider the nonlinear parabolic equation

$$u = L(u) + F(x, t, u)$$

where $L(u)$ is an elliptic operator

$$L(u) = \sum_{i,j} a_{ij}(x)\partial^2 u/\partial x_i \partial x_j + \sum_i b_i(x)\partial u/\partial x_i$$

with the condition that u vanish on the boundary of a bounded, closed, convex domain G for $t \geq 0$. Let F be a nonlinear function of u with the property that $uF(x, t, u) \leq \lambda u^2$ for $x \in G$ and $t > 0$, provided that $|u| \leq K$, a given constant, where λ is a given constant depending upon the domain G and the coefficients above. It is shown that the solution $u = 0$ is stable, which is to say that if $|u(x, 0)| \leq \delta$ for $x \in G$, with δ sufficiently small, then $\lim_{t\to\infty} u(x, t) = 0$ uniformly in x. The method of proof combines the comparison theorems of Westphal and Prodi with the idea of the second method of Lyapunov for ordinary differential equations. Extensions of this result are given for systems. These results constitute generalizations of previous results of the reviewer (for rectangular regions) [*Trans. Amer. math. Soc.* **64,** 21–44, 1948] and Prodi [*Atti Accad. Naz. Lincei Rend. Cl. Sci. Fis. Mat. Mat.* (8) **10,** 365–370, 1951]. R. Bellman, USA

5. Burgers, J. M., Further statistical problems connected with the solution of a simple nonlinear partial differential equation, *Proc. k. Ned. Akad. Wet.* (*B*) **57,** 2, 159–169, Mar./Apr. 1954.

Author applies method developed previously by himself [AMR **7,** Rev. 3964] to a particular problem. Method allows one to consider the behavior produced by periodic "impulses" which give rise to the appearance of wavelike solutions propagating themselves in a direction or developing in course of time. Starting from equation of the type of a reduced Navier-Stokes equation, author finds solution corresponding to steep fronts ("shock waves" or "N-waves," as called by Friedrichs). Next he applies the obtained solution to an initial course described by a chain of parallel straight segments. The method opens a way of approximate approach to some problems connected with correlation problems in the theory of turbulence.

M. Z. Krzywoblocki, USA

6. Blanch, Gertrude, On modified divided differences II, *Math. Tables Aids Comput.* **8,** 46, 67–75, Apr. 1954.

Part 1 [AMR **7,** Rev. 2739] concerned development of the subject. Effects of isolated and multiple errors on higher differences were studied. Part 2 deals with errors due to (a) rounding approximate entries to a fixed number of decimals, (b) errors too small to be considered in part 1, and (c) nonsystematic errors which occur in too many entries to be detected by difference tests. Of interest is extent to which errors of latter type can mask an

isolated error. Probabilistic approach is used. Errors in part 2 of study are assumed to behave like round-off errors, with the added restrictions that errors in entries have the same uniform distribution and are independent of each other. Author derives distribution function of round-off error in first three modified differences, and these are compared with known results for corresponding ordinary differences. Y. Luke, USA

7. **Walsh, J. L., and Young, D., On the degree of convergence of solutions of difference equations to the solution of the Dirichlet problem,** *J. Math. Phys.* **33,** 1, 80–93, Apr. 1954.

In a previous paper [AMR **7,** Rev. 2060], authors studied difference of exact solution of difference analog of Dirichlet problem and solution of Dirichlet problem. Present paper treats degree of convergence of difference-equation solution of Laplace's equation in square as mesh size approaches zero. Error bounds are independent of higher derivatives. Results are an improvement over prior ones and can be extended to rectangles. Authors expect the present results to give an indication of the situation in more general regions. Y. Luke, USA

8. **van den Dungen, F. H., Numerical integration of partial differential equations** (in French), "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris,* 61–70, 1954.

Author shows how initial value problems for the wave equation

$$\partial^2 u/\partial t^2 = c^2 \partial^2 u/\partial x^2 \qquad [1]$$

can be solved numerically by approximating [1] by a system of ordinary differential equations. Author believes that an analogous method can be applied to more general equations, using electronic devices, but he gives no details. W. Noll, USA

9. **Sauer, R., Initial value problems of partial differential equations [Anfangswertprobleme bei partiellen Differentialgleichungen]** (Grundlehren der mathematischen Wissenschaften, Bd. XLII), Berlin, Springer-Verlag, 1953, xiv + 229 pp., 63 figs. DM 29.

The aim of this book is to develop the theory of partial differential equations as a mathematical background for engineers and physicists who work in the field of wave propagation, particularly in fluid dynamics. For this reason corresponding difference equations are also considered, these giving approximate solutions to partial differential equation problems.

The first chapter deals with the peculiarities of initial-value and boundary-value problems for partial differential equations, illustrated by well-known results from potential theory and the linearized wave equations in one space variable. The convergence of finite difference procedures is considered for these examples. The second chapter deals with differential equations of the first order. The concepts of domain of dependence and domain of influence are introduced, as well as the application of the contact transformations to quasilinear equations for two and more variables. Finally, the Hamilton-Jacobi equation of general dynamics is given. In the extensive third chapter, systems of quasilinear equations are considered for two variables. The characteristics are introduced for two quasilinear first-order equations and illustrated by difference equations. The initial value problem is reduced to characteristic coordinates and again the domains of influence and determination are defined. The approximation method by finite differences is given, and bounds for the difference quotients are determined. The iteration method for these differential equations is given for first- and second-order systems. Massau's construction method for characteristic nets is very thoroughly explained. The case of differential equations with straight characteristics is considered separately; also its analog for elliptic equations. Applications are given to geometry of curved surfaces, gas dynamics, surface waves, and plasticity. Propagation of discontinuities is considered and illustrated with nonstationary gas dynamics. Finally, Riemann's method for hyperbolic equations in two variables is presented, initiated by a short account of Green's function for the elliptic case. This again is (as Riemann's own example) illustrated by nonstationary gas dynamics.

In the last chapter, systems with more variables are considered. Again the concept of the Monge cone and Massau's construction are given; quasilinear equations are treated in a separate section, wave points and Huygen's principle are discussed. The remaining part of the chapter is devoted to the Hadamard-Riesz method for linear second-order equations, in particular the wave equation. Poisson's solution of the initial-value problem is given, as well as Huygen's principle; radiation solutions in several dimensions R_1, R_2, R_3 are compared. Finally, Hadamard's method is completely discussed; the finite part of the divergent integrals is introduced by the original procedure. Results are used for a formulation of supersonic airfoil theory.

The book is particularly adapted for its purpose: to present the mathematical foundations of fluid dynamics (supersonic flow). The modern theories of Riesz, which give a more elegant derivation of Hadamard's results and Schwartz's concept of distributions, could not be included in this volume.

But, as reviewer is informed, in a second book the author will deal with these theories and their most useful applications to supersonic airfoil theory. R. Timman, Holland

10. **Mitchell, A. R., Round-off errors in relaxational solutions of Poisson's equation,** *Appl. sci. Res.* (*B*) *3,* 6, 456–464, 1954.

The effects of mesh size and ratio of the magnitude of the round-off errors in relaxation solutions of ordinary and Poisson's differential equations are studied. An approximate solution of the finite difference expression for Poisson's equation is given. Variations of round-off error with constant mesh ratio and constant number of internal nodes are discussed. Numerical results illustrate the use of the procedure. E. D'Appolonia, USA

11. **Mikeladze, M. Sh., Numerical solution for a system of differential equations. Application of the method to the calculation of a rotating shell** (in Russian), *Prikl. Mat. Mekh.* **17,** 3, 382–386, May/June 1953.

Author uses the method of Sh. E. Mikeladze [AMR **5,** Rev. 3295]. It consists of replacing the system of the differential equations with variable coefficients by a system of linear integral equations of the Volterra type of the second kind. For the solution of the latter system, author introduces simple recurrence relations which are easily amenable to numerical calculations. This saves the computer the task of solving a system of complex algebraic equations resulting from the successive approximation method ordinarily used for the solution of Volterra equations. An excellent detailed numerical example from the theory of shells of variable thickness illustrates the application of the method. M. Maletz, USA

12. **Redheffer, R. M., Novel uses of functional equations,** *J. rational Mech. Anal.* **3,** 2, 271–279, 1954.

13. **Curtiss, J. H., "Monte Carlo" methods for the iteration of linear operators,** *J. Math. Phys.* **32,** 4, 209–232, Jan. 1954.

A formal description of the problem treated in this paper is the following: Let $c = c(x)$ and $u_0 = u_0(x)$ be real-valued functions defined over a space which may be multidimensional. Let $L =$

$L(f)$ be a linear transformation operating on the space of functions just defined. We are required to calculate the sequence of functions $u_1, u_2, \ldots$, defined by the recursion formula $u_{N+1} = L(u_N) + c, N = 0,1,2, \ldots$. This problem arises in many physical and engineering problems. For example, the recursion formula just given is obtained when time-dependent diffusion and transport problems are formulated in discrete form. The methods in this paper are an outgrowth of a stochastic (probabilistic) attack on diffusion problems by von Neumann and Ulam. Their idea was to solve such problems by means of a computing procedure having various random decisions in it which closely imitate the physical phenomenon under study. This kind of approach is well known to statisticians who frequently must resort to random sampling experiments when the calculations of exact distributions become too difficult and involved to carry out analytically. In physics, such random experiments are called Monte Carlo experiments.

The interesting feature of the present paper is the application of Monte Carlo methods to nonstochastic problems, such as numerical quadrature and matrix inversion. Since no natural stochastic base exists in these problems, the statistician has at his disposal a whole class of Monte Carlo methods for solving any given problem. The author raises the important question of how one chooses a "best" sampling procedure from among this class. This amounts to choosing a Monte Carlo method which achieves a specified statistical accuracy with less sampling (fewer steps in the Monte Carlo method) than any other method. The author shows how one finds a best Monte Carlo method in the numerical quadrature case. In the matrix inversion case, he compares the variances of two Monte Carlo procedures, one of which was proposed by G. E. Forsythe and R. A. Leibler [*Math. Tables Aids Comput.* **4**, 127–129, 1950] and the other by W. Wasow [ibid., **6**, 78–81, 1952]. Further, he proposes a modified Forsythe-Leibler procedure which has a smaller variance than the original procedure.

To sum up in the author's own words: "The idea here is merely to present some theory which may be of some interest for itself alone, and which unifies and clarifies certain of the Monte Carlo devices which have been proposed, and which lays the groundwork for further numerical experimentation aimed at investigating the limits of usefulness of the method for nonstochastic problems." B. Epstein, USA

14. Dantzig, G. B., and Orchard-Hays, Wm., The product form for the inverse in the simplex method, *Math. Tables Aids Comput.* **8**, 46, 64–67, Apr. 1954.

The simplex method is an algorithm for determining values for a set of n nonnegative values which minimizes a linear form subject to m linear restraints. It is a finite iterative procedure and is particularly effective for solving problems in operations research (e.g., transportation model, dynamic economic and production models, etc.). Paper presents a modification of simplex method which reduces computation time. Technique for application on CPC is indicated. Y. Luke, USA

15. Maxwell, J. C., A treatise on electricity and magnetism, Vol. I, II, republication of 3rd rev. ed., New York, Dover Publications, Inc., 1954, xxxii + 506 pp., 39 figs., 13 plates; xxiv + 500 pp., 68 figs., 7 plates. $4.95 (bound as one).

16. Kellogg, O. D., Foundations of potential theory, New York, Dover Publications, Inc., 1953, x + 384 pp. $1.90.

This new edition is an unaltered and unabridged reissue of the first edition which appeared in 1929 (Berlin, Springer-Verlag). Ed.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 11, 208, 218, 287, 314)

17. Rosenauer, N., Acceleration centre curves, *Austral. J. appl. Sci.* **5**, 2, 103–115, 1954.

Treatise contains a grapho-analytical method for determination of the acceleration-center G for a plane motion in both moving and fixed planes. Equations representing the acceleration-center curves are found in parameter form. Author derives the coordinates of G from a graphical construction for the determination of G. This construction is based on the Joukowsky theorem.

The method of subject matter is developed to overcome a disadvantage very often encountered by using purely graphical constructions. Inaccurate solutions are to be expected when intersections of straight lines or circles occur at small angles.

For example, the presented method is used for the determination of the acceleration curves of the connecting rod of a slider-crank mechanism.

For the same purpose, a practical grapho-analytical method for the determination of G has been developed by K. Federhofer [see *ZAMM* **13**, 3, 243–244, June 1933], although Federhofer has not, in this paper, dealt with the acceleration center curves. J. Boehm, USA

18. deJonge, A. E. R., The motion of a link chain over a roller, *Trans. ASME* **75**, 5, 747–757, July 1953.

Trouble encountered in the operation of large ledge-cutting-type excavators, containing link chains moved by hexagon tumblers and guided by deflection rollers, resulted in the analysis reported in this paper. The tumbler difficulty was easily traced to the tendency of the links to climb the straight-face teeth. Substitution of curved tumbler teeth eliminated this difficulty.

Analysis of link action over the roller proved more troublesome. A general analytical solution of roller action results in equations of at least third degree, containing two or three interdependent variables. Solution by this approach does not prove feasible. Thus a graphical method is undertaken. It is shown that a troublesome variation can and did exist in the pulling force of the leading link. To prevent or at least reduce this variation, it is necessary (and sufficient) to have a minimum of three links in contact with roller at all times. A practical equation establishing the required relationship between the roller radius and the chain-link length to satisfy the three-link requirement is derived. When rollers defined by this equation were installed, the excavator difficulty disappeared. J. P. Vidosic, USA

19. Puwein, M. G., Duration of the oscillation of physical pendulums with finite amplitude (in German), *Öst. Ing.-Arch.* 8, 1, 54–55, Feb. 1954.

20. Belts, chains, clutches [Riementriebe, Kettentriebe, Kupplungen] (Schriftenriehe Antriebstechnik, Heft 12, VDMA), Braunschweig, Friedr. Vieweg & Sohn, 1954, 262 pp. DM 24.50.

Book contains papers and discussions presented at a conference on drive elements held at Essen in 1953.

Topics include limits of torque and power transmission for title elements, problems of calculating and fashioning belt drives, flat leather belts, synthetic belts, endless V-belts, theory of chain drives, examples of chain applications, inverted tooth chains, chain tighteners and vibration dampers for high-speed chain drives, types of couplings and clutches, flexible couplings and clutches for periodically varying torque, torque-limiting couplings, mechanical friction couplings, and synchronizing clutches for gear transmissions.

Should be of interest to all engineers dealing with power-transmission equipment. A. S. Hall, USA

21. **Heumann, H., The principles of guidance of rail vehicles** (in German), *Elektrische Bahnen* **21, 22, 23, 24,** nos. 4, 5, 8, 11, 12; 5, 6, 11, 12; 7, 8: 4, 5, 11, 12, 1950, 1951, 1952, 1953.

This is a monumental paper embracing over 150 pages, 179 illustrations, and 358 numbered equations. It is the summary of the results of over 40 years of research into the theory of the motion of flanged wheels on rails and the stresses in the horizontal plane resulting from running in the straight and through curves of vehicles ranging from four-wheel trucks to articulated locomotives. These investigations are based on a graphical-analytical method developed by the author and widely used in Europe where the author is the acknowledged leader in this field.

Following an introduction dealing with the fundamental aspects of wheel motion and resultant forces, the author considers the geometry of wheel-to-rail contact and the mechanics of sliding through curves. The second part deals with the position of vehicles in curves, the effect of centering mechanisms on transverse forces, and the forces due to and position in curves of vehicles with transversely rigidly located axles. The third part considers rail guide forces and position of vehicles with three and more axles and the action of articulated vehicles (incorporating Baldwin-Beugniot bogies, Garrat, Fairlie, Liechty, Bissel, Helmholtz, Lotter, Eckhardt, etc., arrangements), and this matter is then treated in further detail in the fourth part where the author considers locomotive arrangements with regard to the stresses set up when passing through curves. The fifth part deals with bogies incorporating two strictly parallel and transversely rigid axles, an arrangement of great importance with carriage bogies and with high-speed electric and Diesel locomotives, and considers two free axles as well. The sixth part is devoted to the difficult subject of the action of vehicles passing through curves with varying radii and when running into or out of curves. Here again the flange stresses are considered in great detail for a number of typical vehicle arrangements. The seventh part deals with forces imposed upon wheel flanges when running under a wide variety of conditions and the interaction of these forces in the vehicle frame. Consideration is also given to forces encountered during sliding or near-sliding, the mechanics of derailment, curve-resistance mechanics, and wear mechanics of wheel flanges and rail. The running on straight track, the mechanics of the sinusoidal motion of conical wheels on "free" axles and axles restrained in the bogie, and of single-axle bogies, and the resultant stresses are dealt with in the last part.

The paper is a tour de force which will have far-reaching consequences on the understanding of flange stresses and guide mechanics and consequent impact on design. It is recommended without qualification to every student of rail vehicle mechanics who wishes to learn the complex subject as it should be learned and to every engineer who wishes to understand vehicle behavior and, in turn, to improve the design. Undoubtedly, another paper of this scope will not appear for many years and the publishers deserve thanks for the promised publication of an enlarged version of this paper in book form, thus considerably enriching technical literature devoted to railway mechanics.

J. L. Koffman, England

22. **Santangelo, G., On the fastest coordinated turn** (in Italian), *Aerotecnica* **33,** 2, 158–163, Apr. 1953.

Paper deals with the problem of finding that flight path which brings an aircraft from a given initial direction into another predetermined direction within the shortest possible time. The general equations of motion for an unsteady coordinated turn are transformed into a relation between the rate of turn and the velocity, which can be solved with respect to the time element dt. Integration of this equation gives the variation problem. A first integral of the pertaining Eulerian equation is obtained and the possible cases of right and left, accelerated, and decelerated turns are discussed. If the thrust is a polynomial in the first three even powers of the speed, the integration of the Eulerian equation can be reduced to elliptic integrals. For more general thrust laws the integration can be performed by expansion in a McLaurin series. The coefficients of this series are expressed as functions of the initial speed and load factor. If the thrust is independent from the speed, the differential equation can be integrated by elementary functions. For this case a schematic example is given. G. W. Braun, USA

23. Simelev, G. V., Theory of the automobile [Teoria avtomobiliya], Moscow, Publ. by War Ministry, 1951, 400 pp. $1.

Book is written to provide guidance on design theory and methods of experimental determination.

Contents: Basic parameters of Russian cars and lorries (14 pp.); Mechanics of wheel rolling (13 pp.); Vehicle motion (26 pp.); Tractive effort as determined by adhesion (39 pp.); Tractive resistance (59 pp.); Determination of tractive performance (100 pp.); Tractive economics (34 pp.); Determination of design parameters (37 pp.); Stability (22 pp.); Vibrations (46 pp.)

The text is essentially a mathematical treatment of the application of classic mechanics to the determination of automobile performance. It contains considerable data on Russian cars and results of component performance determinations. Reviewer found considerations of weight transfer problems and graphic vehicle performance determinations of particular interest. The chapter on resistance contains aerodynamic data extensively abstracted from elsewhere without revealing either fact or source. The chapter on stability is most inadequate, making no mention of effect of tire slip angle, location of drive, aerodynamic pressure center, and directional oscillations.

Vibration considerations are mainly based on Lehr's work and are too brief. Apart from this, the reviewer is of the opinion that the text meets the requirements for a clear introduction into the complexities of automobile mechanics.

J. L. Koffman, England

24. Velikanov, D. P., Operating characteristics of our automobiles [Ekspluatacionie kachestva otechestvennih automobilei], Moscow, Mashgis, 1953, 166 pp., 63 figs. 6 rub., 15 kop. ($0.75)

Book was written to facilitate evaluation of operating characteristics of automobiles and thus sponsor further development. The economics of operation are considered on the basis of data of six lorry types, six passenger-car types, and six bus models. The tractive performance, engine-performance data, and detailed vehicle data are considered next and the results of experimental time-velocity determinations and brake performance data are given in considerable detail, together with the results of official vehicle tests over various road types. Details are given of fuel-consumption characteristics determined for a wide variety of conditions, while wear problems are considered with particular reference to cylinder wear, which is treated in some detail. The results of official long-distance tests are given and attention drawn to the main weaknesses of a number of vehicles. Stability is considered in general terms for a number of cars and lorries together with passenger-comfort parameters and the ease of lorry loading. Ease of control is analyzed on the basis of extensive testing, and data are given of the number of gear changes per 100

Km when operating over a wide range of conditions. The sizes of drivers' cabs and seats are critically reviewed, together with the reliability and utility of the instrument arrangements. Fuel capacity and resultant mileage of most passenger and goods vehicles are considered, and tire wear and turning circles briefly dealt with. A chapter is devoted to the effective utilization of lorries in terms of load tare and maintenance procedures, stressing the weak points of the different types with resultant suggestions for future improvements. A table extending over seven pages gives detailed dimensions and performance data of the Moscvich, Pobeda, SIM and SIS-110 cars, and GAS-51, SIS-150, and JAS-200 lorries.

The reviewer found the chapters on fuel consumption and engine cylinder wear of particular interest. The book is informative and stimulating and thus achieves its professed aim to sponsor improvement of vehicle performance via suitable evaluation testing. It can be recommended to engineers interested in vehicle performance in general and that of Russian vehicles in particular. J. L. Koffman England

Servomechanisms, Governors, Gyroscopics

(See also Rev. 188)

25. Pack, G. J., and Phillips, W. E., Jr., Analog study of interacting and noninteracting multiple-loop control systems for turbojet engines, *NACA TN* 3112, 33 pp., Mar. 1954.

The effect of compensation terms for reducing an interacting multiple-loop system to separate noninteracting loops is shown for proportional and proportional-plus-integral controllers.

Computer studies show that the addition of integral terms makes the system slower and more oscillatory, but that they are desirable because they make the system parameters independent of the disturbance source. Addition of compensation terms results in considerable improvement.

Inclusion of quantitative data would give more weight to authors' explanation of some of the discussed phenomena.

A. C. Block, USA

26. Gold, H., Otto, E. W., and Ransom, V. L., An analysis of the dynamics of hydraulic servomotors under inertia loads and the application to design, *Trans. ASME* **75,** 7, 1383–1394, Oct. 1953.

The problem of analyzing and developing design criteria for hydraulic servomotors in order to insure their meeting specified dynamic response requirements has been a predominant one in the control field. Paper presents a very approximate mathematical approach applicable only to those servomotors having primarily inertia loads. Method consists essentially of describing performance by two different differential equations, one for acceleration and one for the deceleration period of the response to a step-function input; the transition from one relation to another is established at the point where the response curves merge together. Standard assumptions necessary to make the method amenable to analytic treatment have been made; e.g., assumption of port areas proportional to pilot displacement, of negligible fluid friction losses in motor, and of negligible mechanical friction. Discussion points out that method would not apply to most servos used to actuate aircraft control surfaces (where hinge moments constitute the primary load) or to cases where oil flow limitations cause limiting to occur.

As mentioned by discussers, lack of mathematical rigor raises severe questions concerning validity. However, remarkably good agreement between calculated and experimental results is shown by authors. Further experimental correlation would be required to prove that this agreement is general rather than merely due to fortunate selection of test conditions. If such further study substantiates accuracy of method, it will provide valuable criteria for selecting optimum design parameters and for predicting servo performance. R. Kochenburger, USA

27. Gold, H., Otto, E. W., and Ransom, V. L., Dynamics of mechanical feedback-type hydraulic servomotors under inertia loads, *NACA Rep.* 1125, 21 pp., 1953.

Supersedes article reviewed in AMR **6,** Rev. 731.

28. Muller-Girard, O., The dynamics of filled temperature-measuring systems, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-29, 10 pp.

The dynamic behavior of liquid-filled tube temperature-sensing systems affects the stability and attainable quality control of automatic industrial temperature-control processes. Response equations for an approximate, two-time constant, interacting network analogy are obtained. Solutions to a unit step, ramp, and sinusoidal temperature input are given. Experimental data from mercury-filled thermal systems are compared with calculated results from the network analogy and shown to be in substantial agreement for the region of interest in automatic control problems. Recommendations are made concerning the specification of the speed of response of these systems.

E. L. Foster, USA

Vibrations, Balancing

(See also Revs. 19, 200, 298)

29. Weibull, H., Computation of oscillation spectrum for test rods, *IngenVetenskAkad. Tidsk. Tekn. Forsk.* **25,** 4, 171–173, 1954.

If the elastic constants of a material are determined from the natural frequencies of test bars, it is often difficult to decide to which vibration mode the frequency belongs (lateral, torsional, or longitudinal) and whether it is the fundamental or a higher natural frequency, or even a frequency originating from the test apparatus. It is shown, and the formulas are presented, that with rods from a homogeneous and isotropic material the frequency spectrum, defined as the ratio between the various undamped natural frequencies and the fundamental bending frequency, can be determined irrespective of the elastic constants of the material. R. G. Boiten, Holland

30. Budiansky, B., and Kruszewski, E. T., Transverse vibrations of hollow thin-walled cylindrical beams, *NACA Rep.* 1129, 10 pp., 1953.

Supersedes article reviewed in AMR **6,** Rev. 1173.

31. Palmer, P. J., The natural frequency of vibration of curved rectangular plates, *Aero. Quart.* **5,** part 2, 101–110, July 1954.

Rayleigh's method is applied to the problem of the vibration of curved plates with two (constant) radii of curvature and "rectangular" boundaries. Detailed results are given graphically for a few cases involving the extensional mode—that mode in which the points of the middle of the plate are assumed to be displaced in a purely radial direction. Results are also given for a few cases of plates with simply supported edges vibrating in the inextensional mode, that mode in which all three strain components are zero for the middle of the plate. For the extensional mode, a symmetrical deflection shape is assumed; for the inextensional mode, an asymmetrical deflection shape.

Results of the cases studied in this manner indicate that, for shallow plates, the extensional mode has the lower frequency; but for deep plates, the frequency of the inextensional mode is lower. E. J. McBride, USA

32. **Reissner, E., On axi-symmetrical vibrations of circular plates of uniform thickness; including the effects of transverse shear deformation and rotatory inertia,** *J. acoust. Soc. Amer.* 26, 2, 252–253, Mar. 1954.

Note shows that the solution of the problem described in the title of this note may be expressed in terms of Bessel functions in such a manner that the results reduce to the well-known results of Kirchhoff when transverse shear deformation and rotatory inertia are neglected. From author's summary

33. **Dieudonné, J., Torsional vibrations,** *Inter. Shipbldg. Progr.* 1, 1, 29–38, 1954.

The object of the present paper is to collect the works of various writers who have published articles on the damping of torsional vibrations by the engine itself.

From author's summary

34. **Corbetta, G., On the calculation of flexural vibrations of the crankshaft of double-row radial engines** (in Italian), *Aerotecnica* 34, 1, 23–26, Feb. 1954.

The shaft is supposed to be mounted in three immovable bearings, the masses are concentrated in four points: the two cranks and the two counterweights. The frequency calculation is by the classical method involving influence functions.

J. P. Den Hartog, USA

35. **Morris, J., Resonant vibration of helicopter rotor blades,** *Aero. Res. Counc. Lond. Rep. Mem.* 2801, 4 pp., June 1950, published 1954.

The blades of the operative rotors of helicopters are usually hinged both in the lift and rotational planes, and it is because of this articulation that the blades in the course of rotation are akin dynamically to "pendulum vibration dampers."

If the fundamental frequency of this species of pendulum vibration is numerically equal to nN, where n is the number of blades and N is the frequency of rotation of the rotor, then serious resonant forced vibration may ensue and it would appear that this is quite likely to occur in practical cases with the blades in vibration in the plane of rotation of the rotor.

From author's summary

36. **Tlusty, J., Self-excited vibrations of machine tools** (in German), *Acta Techn. Hung. Budapest* 8, 3/4, 319–360, 1954.

Laboratory test to determine self-excited vibration on lathes, milling machines, planers, vertical shapers, and gear cutters. Theoretical information is supplied as well as discussion of measuring equipment and models used. Data include relative motion between tool post and workpiece, frequency, exciting force, vibration of the tool post and the workpiece itself. Self-excited vibrations were found to decrease with improved rigidity of the feeding mechanism and provision of a damping device.

A. O. Schmidt, USA

37. **Ishchlinskiĭ, A. Yu., On an integrodifferential relation in the theory of elastic threads (ropes) of variable length** (in Russian), *Ukrain. Mat. Zh.* 5, 4, 370–374, 1953. (English translation by M. D. Friedman on file with Scientific Translations Division, Library of Congress.)

Author obtains the differential equation for the time-dependent deformation of an end-loaded vibrating cable running over a pulley. Weight of cable is included.

Starting with the appropriate differential form of Newton's law, assuming an approximate form for the deformation, integrating by parts, and then substituting the boundary conditions and the assumed deformation, an approximate differential equation governing the phenomenon is obtained.

No indication is given of application or use of the derived equation. S. F. Borg, USA

Wave Motion, Impact

(See also Revs. 166, 265, 278)

38. **Mintzer, D., Wave propagation in a randomly inhomogeneous medium. III,** *J. acoust. Soc. Amer.* 26, 2, 186–190, Mar. 1954.

This paper is a sequel to a paper [AMR 7, Rev. 1027] in which was discussed the problem of the fluctuations in pressure amplitude of pulsed sound from a point source arising from variations in the refractive index of the medium. In a second paper [AMR 7, Rev. 2686], it was shown that the assumption of single scattering made in part I was a valid approximation in the range in which experimental results were available. The second basic assumption made in part I was that the pulse length was such that the refractive index at a point of the medium did not change appreciably during the time it took the pulse to pass the point, but only during the time between pulses. It is this assumption which is examined in the present paper. Using some rather general assumptions, author shows that this second assumption is valid only if the pulse length is very much less than the parameter of the correlation function of the refractive index. Comparison is made between the theory and the experimental findings of Sheehy. I. N. Sneddon, England

39. **Khaskind, W. D., Diffraction of waves around a cylindrical vessel in motion** (in Russian), *Prikl. Mat. Mekh.* 17, 4, 431–442, July-Aug. 1953.

Heavy incompressible fluid streams around a vessel (ship) in direction of the axis. Superimposed to the steady flow is a small stationary wave field of arbitrary direction. There is neither internal nor skin friction and therefore a scalar velocity potential. Problem is immediately reduced to two-dimensional form and further treated for rectangular ship shape with either vanishing width or vanishing depth. By introduction of elliptic coordinates mapping of field into a rectangular strip is achieved in each case.

Resulting forces and moments on ship are given. In the second instance formulas contain two constants defined only by an infinite system of linear equations. There are some misprints. Paper is surely of interest, though of restricted applicability.

G. Plato, Germany

40. **Nougaro, J., Theoretical and experimental study on the propagation of transmission waves in open canals** (in French), *Publ. sci. tech. Min. Air, Paris* no. 284, 155 pp., 1953.

Waves of transmission in canals and in rivers may be studied from two different points of view. We may suppose that, in a hydroelectric plant, the discharge increases or decreases slowly during the day; we then have, in the river, transmission waves which gradually change, studied for the first time by Boussinesq (neglecting losses) and afterward by Puppini (1933), Bonvicini (1934), Masse (1935), etc.

Waves of transmission, however, may be considered also in canals conveying water to the turbines and in canals carrying water from them; in these canals, a sudden increase of discharge in the turbine gives a depression wave in the canal conveying water and a positive wave in the canal carrying the water from

the turbine. These waves have been considered by Bergeron (1937), Henry (1938), Craya (1946), etc., and now are studied by author.

Book is divided into 9 chapters. The introduction gives general knowledge on transmission waves of this kind. The second chapter studies the wave velocity; it is a very interesting chapter because theoretical formulas are compared with experimental results. Neglecting losses, author deduces four theoretical formulas, but it is shown that, in a short canal, the experimental wave velocity is included between $[gH_0(1 + 3h/2H_0)]^{1/2} \pm U_0$ (U_0,H_0 depth and velocity in the uniform motion, h height of the wave, g constant of gravity) and $[gH_0(1 + h/H_0)]^{1/2} \pm U_0$. In a long canal, head losses have some importance in reducing wave velocity; for this case, author gives the formula $a = [g(H_0 + h)/(1 + m)]^{1/2} \pm U_0$ where $m = ghL/H_0k^2R^{4/3}$ (L length of the canal, R hydraulic radius, k coefficient of roughness in Strikler's formula). Experiments in laboratory of Toulouse (with a canal of 24 m of length and 0.4 m in width, with roughness artificially increased with two wired nets near the two walls) confirm the formula.

Wave velocity is reduced also by losses due to a sudden contraction or enlargement of the canal (and for this case another formula is given, confirmed by experiments), while the wave velocity in a tunnel with surge tank is studied only from the theoretical point of view.

Chap. 13 studies the wave propagation as a whole, considering wave reflections in canals in the same manner as Bergeron has considered wave reflection in pipes (in water-hammer problems). Indeed, Bergeron gave the same graphical method for water hammer in pipes and for waves in canals; but Nougaro not only reports the Bergeron method but also gives some extensions of it. A first extension considers the main velocity of the water in canal (before the wave establishment), while a second extension, starting from a research of Mr. Remenieras, introduces curved characteristics. For every extension an experimental confirmation is reported.

Chaps. 4 and 5 are devoted to developing a new method due to the author: in the fourth chapter the head losses are neglected, while in the fifth they are considered together with the slope of the bottom. In this chapter also studied is the effect of the bifurcation of the canal, enlargements, etc. Researches of chapters 4 and 5 are only theoretical. But chaps. 6, 7, and 8 consider experimental result. In chap. 6 we find a description of experimental dispositions and of measurement apparatus. Chap. 7 is devoted to experiments in scale models; chap. 8 compares theoretical results with experiments, not only in scale models but also in canals of hydroelectric plants. Exposition considers always the head losses, but in studying the Saint-Christaud plant the minor losses are also evaluated.

Book closes with a chapter (the 9th) presenting graphs for simplifying calculations.

It must be pointed out that the book (which is, in fact, a long memoir) is devoted to a very important problem of modern hydraulics and that results on wave velocity and propagation are very interesting. G. Supino, Italy

41. Harrison, W., The propagation of elastic waves in a plate, *David W. Taylor Mod. Basin Rep.* 872, 11 pp., Jan. 1954.

Starting with the idea of plane dilatational and shear waves in a slab, their direction of propagation inclined to the stress-free surfaces of the slab, author derives the classical dispersion equation obtained by Lamb [*Proc. roy. Soc.* **93,** 1917]. Significant contribution is the discussion of the connection between the higher-mode dispersion curves and directions of travel of plane waves. Interesting case of fluid slab is also discussed.

H. J. Plass, Jr., USA

42. Fischer, H. C., Stress pulse in bar with neck or swell, *Appl. sci. Res.* (*A*) **4,** 4, 317–327, 1954.

Author discusses the problem of the longitudinal impact of two bars, one of which is short and the other long; the lateral dimensions of the bars are identical except for a section of the latter where the area is either greater ("swell") or less ("neck") than the normal. The impact is assumed to initiate a square-topped pressure pulse whose length in the longer bar is equal to twice the length of the shorter bar. The reflection and transmission of this pulse at the discontinuities in area are discussed theoretically by the stereogram method used by De Juhasz [AMR 4, Rev. 94]. Some of the calculated results are tested by measuring the transient strains in the longer bar with resistor strain gages; the agreement between theory and experiment is satisfactory when allowance is made for the differences between the assumed and actual forms of the stress pulse initiated at impact.

R. M. Davies, Wales

Elasticity Theory

(See also Revs. 33, 42, 55, 56, 63, 73, 74, 79, 88, 89, 225)

43. Miller, G. F., and Pursey, H., The field and radiation impedance of mechanical radiators on the free surface of a semi-infinite isotropic solid, *Proc. roy. Soc. Lond.* (*A*) **223,** 1155, 521–541, May 1954.

Authors obtain complex-integral representations for the components of displacement at any point of an isotropic elastic semispace, subjected to the following sinusoidally time-varying stress conditions on its plane boundary: (a) normal component of traction uniform along an infinitely long rectangular strip, tangential components of traction zero; (b) tangential component of traction, perpendicular to edge of infinitely long strip, uniform along strip, other two components of traction zero; (c) normal component of traction uniform over a finite circular area, other components of traction zero; (d) the shear stress $\tau_{r\theta}$ linearly varying distance from pole, over a finite circular area, other two components of traction zero. In all four cases, the three components of traction are zero over the remainder of the boundary.

Unfortunately, three of these loading conditions have already been studied. A generalization of (a), which is a problem in plane strain, appears in I. N. Sneddon, "Fourier transforms" [MR **4,** Rev. 3753], p. 445. Problems (c) and (d) were discussed by E. Reissner in *Ingenieur-Archiv* **7,** 381–396, 1936, and **8,** 229–245, 1937, respectively. Problem (b) appears, to the reviewer, to be new.

Authors define radiation impedance in cases (a), (b), (c) as "the ratio of stress to mean displacement velocity under the radiator in the direction of applied stress"; in case (d) as "the ratio of the total torque to the product of the moment of inertia of the source and the mean angular displacement velocity under the radiator." Some numerical values of the impedance are tabulated. H. Deresiewicz, USA

44. Signorini, A., An extension of the linear theory of elasticity (in German), *Öst. Ing.-Arch.* **8,** 1, 47–53, Feb. 1954.

Without postulating the existence of a natural (unstressed) state of the solid, author studies certain very general, reversible transformations in the elastostatics of isothermal deformations. The result is an identity which differs from its classical counterpart to the extent only that it is based on a quadratic form in nine rather than six variables. From this identity it then follows that the well-known fundamental theorems in classical theory of elasticity—e.g., minimum energy, Betti's theorem etc.—have their exact analogies in the generalized theory.

H. Parkus, USA

45. **Saroja, B. V., The torsion of solid regular hexagonal shaft by relaxation methods,** *J. Indian Inst. Sci.* (*B*) **36,** 2, 37–42, Apr. 1954.

Following the method described by Southwell ["Relaxation methods in theoretical physics"], author has solved the problem for a geometric shape that does not seem to have been previously described in the literature. Author demonstrates the use of Southwell's technique for the "advance to a finer net." The stress function has been calculated using a triangular net whose size is $^1/_9$ that of the side of the hexagon. Unfortunately, the author has neglected to calculate the maximum shear stress although he has listed the defining relationships for the stresses in terms of the derivatives of the stress functions.

A. L. Ross, USA

46. **Herzig, A., On torsion of rods** (in German), *ZAMM* **33,** 12, 410–428, Dec. 1953.

An exact solution is given for the torsion of prismatical bars whose cross sections are a semicircle, a quarter of a circle, and a circle with a radial slit. The warping function of the Saint Venant theory of torsion (i.e, the displacement of a point in the direction of the axis) is determined with the aid of the conformal mapping of the three cross sections on the unit circle.

The values obtained for the torsional rigidity and the maximum shearing stress are as follows:

half circle: $C = G[(\pi^2 - 8)/2\pi]R^4$; $\tau\max = G\theta(8R/3\pi)$
quarter circle: $C = G[(\pi^2 - 12\log_e 2)/6\pi]R^4$; $\tau\max = 0.598G\theta R$
slitted circle: $C = G[(9\pi^2 - 64)/9\pi]R^4$; $\tau\max = G\theta(8R/3\pi)$

In the last case, there occur probably larger stresses at the periphery of the slit, but these have not been calculated. It is seen that the effect of a radial slit is to diminish the torsional rigidity to 55.9% of its original value. Ch. Massonnet, Belgium

47. **Malavard, L., and Boscher, J., Application of network iteration methods for the study of different problems in elasticity** (in French), *C. R. Acad. Sci. Paris* **238,** 10, 1093–1094, Mar. 1954.

48. **Ikeda, S., and Ueno, I., Equivalent bending and torsional rigidity of wire rope and stress induced in elementary wire of wire rope when it is bent along the sheave,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 199–208.

The wire rope is composed of a central and several side strands. Equivalent bending and torsional rigidity of each strand being determined, those of the wire rope are calculated. Authors then deduce the values of the stress in elementary wire of rope bent along the arc of a sheave, having obtained the bending stress in central wire, bending and torsional stress in side wire, and stresses induced in elementary wire of rope of central and side strands. Characteristic bending curve is drawn to show the stress induced in the bent rope. D. N. Mitra, India

49. **Mitchell, L. H., A Fourier integral solution for the stresses in a semi-infinite strip,** *Quart. J. Mech. appl. Math.* **7,** part 1, 51–56, Mar. 1954.

The stresses in a semi-infinite plate with stiffeners are analyzed. The Airy stress function is determined for prescribed stresses at the boundary under the following conditions: (1) The stiffeners are of the same material as the plate; (2) they are assumed to resist only normal axial stresses which are constant over any cross section; (3) the edge of the plate is free from shear stresses.

An example is calculated and its results compare favorably with the author's photoelastic investigations.

W. Ornstein, USA

50. **Rostovtsev, N. A., Complex functions of stress in an axially symmetric contact problem of the theory of elasticity** (in Russian), *Prikl. Mat. Mekh.* **17,** 3, 611–614, Sept./Oct. 1953.

Author gives a method of computing the field of stresses and displacements in axially symmetric frictionless case. For this method the computation of Newtonian potential is not necessary and the solution is reduced on a few quadratures. It is shown how the method can be applied to the case of a rectangular and cylindrical die. Z. Horák, Czechoslovakia

51. **Nishikawa, J., A general method for solving two-dimensional problems by means of Fredholm's integral equations,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 169–177.

Author starts from a representation of Airy's function in the form of a boundary integral, containing two unknown functions of the boundary coordinate. The differential equation of the stress function being satisfied, the boundary conditions lead to integral equations of the Fredholm type. H. Neuber, Germany

52. **Negoro, S., and Sekiya, T., On a method of solving the so-called elastic plane stress problems,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 179–184.

Author recommends a numerical method of differences based on a two-dimensional interpolation formula and gives two examples concerning a quadratic domain. H. Neuber, Germany

53. **Kikukawa, M., On a method of calculating stress concentration in an infinite plate with a hole of an arbitrary profile,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 185–191.

Using complex variable methods due to Muskhelishvili, problem is solved by successive approximation. Function which maps exterior of hole on interior of unit circle is also obtained by an iterative process. Numerical results are given for rhombic hole with circular fillets in plate under uniform tension at infinity.

A. E. Green, England

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 30, 37, 46, 48, 49, 64, 65, 72, 83, 89)

54. **Bergfelt, A., Elastically supported beams** (in Swedish), *Tekn. Tidskr.* **84,** 14, 311–313, Apr. 1954.

Linear theory of beams on elastic foundation is extended to cover influence of shear. Deflection also in this case appears as damped sines and cosines, damping and wave length being greater due to shear. Application of theory to beam on pile work shows 7–15% increase in reaction on piles and 2–5% decrease in maximal moment. Theory can also be used for shells where correction appears negligible. Measurements on nails in concrete seem to confirm theory to some extent.

J. Hult, Sweden

55. **Sawsa, H., On the elastic winding of circular wire,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 129–133.

Obtaining the normal stress at a point on the cross section of a circular wire wound round a circular mandrel in a manner analogous to the simple bending of a bar, the total tension acting on the wire is expressed in terms of the radius of the mandrel, that of the wire, the distance of the neutral line in the cross section of the wire from the axis of the mandrel, and Young's modulus of wire. Elastic stress components and principal stresses at a point are

solved under assumption of a large elastic limit, radius of the wire being considered small. These principal stresses are employed in Nadai's yield condition to assess approximately the elastic-plastic boundary and the plastic region, corresponding to the yield strength of the material. Calculated numerical results for molybdenum wire are presented in diagram.

D. N. Mitra, India

56. Yoshida, S., Studies on the torsional stress-strain characteristic of a bent wire, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 123–127.

Considering the cross section of the bent circular wire to be partly elastic and partly plastic, author determines the torsional moments of such wire under the assumption that, in plastic region (i.e., after yielding has reached), (1) tensile stress σ of wire is constant and equal to that when it just yields; (2) torsional stress-strain plot beyond the yield point is linear, either parallel or makes an angle with the direction of strain axis; (3) shearing stress τ is given by $\sigma^2 + 4\tau^2 = \text{const}$. Theoretical torsional stress-strain characteristic curves of copper, aluminum, and steel wires are plotted and compared with experimental ones and the author claims the results to be in good qualitative agreement.

D. N. Mitra, India

57. Dudley, F. E., Electronic control method for the precision expanding of tubes, *Trans. ASME* **76,** 4, 577–582, May 1954.

Plates, Disks, Shells, Membranes

(See also Revs. 11, 31, 32, 41, 67)

58. Matl, F., Calculation of settlement and inclination of an eccentrically loaded rigid slab (in German), *Öst. Bauzeitschr.* **9,** 4, 65–70, Apr. 1954.

Using the results of theoretical investigations carried out by Michell and Fröhlich for the deformations of an elastic-isotropic layer of finite thickness, author deduces formulas for the settlements of an eccentrically loaded rigid slab founded on elastic ground. Diagrams are given for the practical use of the formulas.

As an example, the inclination due to earth pressure of a retaining wall founded on a clay layer has been calculated.

K. J. Sundquist, Sweden

59. Teodorescu, P. P., On the exact theory of the equilibrium of cylindrical surfaces (in Romanian, with Russian and French summaries), *Acad. Repub. Pop. Romane. Bull. Sti. Sect. Sti. Mat. Fiz.* **4,** 111–194, 1952.

Author considers the Love theory of cylindrical shells in the formulation for anisotropic materials given by Girkmann [Flächentragwerke, Springer, Vienna, 1946, 323–331, 348–422]. His objective is to obtain a general solution which can be adapted to fit boundary conditions. This work contains probably the most extensive application of the matrix method of Gr. C. Moisil yet presented. [This method has been illustrated in many recent Romanian papers, most of which refer to a book by Moisil, "Matricele asociate sistemelor de ecuatii cu derivate partiale," Bucarest, 1950, which the reviewer has not been able to see.] The author shows (¶9) that all three displacements satisfy a single homogeneous linear partial differential equation of eighth order with constant coefficients, these latter being very elaborate functions of the elastic moduli of the material (Appendixes 1 and 2). Next (¶11) he shows that the displacements may be expressed as linear combinations of fifth derivatives of a single function satisfying the above equation, the coefficients again being elaborate functions of the elastic moduli (Appendixes 3 and 4). Various associated differential equations are discussed in §§3–4. Most of the rest of the paper (§§5–7) concerns the simplifications resulting in various special cases or approximations. These special cases are not individual problems but rather classes of problems defined by the vanishing of certain resultants: the extensional ("membrane") theory, Finsterwalder's theory, Dischinger's theory, etc. In §8 the author discusses the numerical magnitudes of some of the coefficients for anisotropic bodies. A great deal of labor has gone into this work. C. Truesdell, USA

60. Kumai, T., Elastic stability of the square plate with a central circular hole under edge thrust, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 81–86.

The approximate value of the critical load of the plate is computed by the energy method, using a deflection pattern that satisfies the boundary conditions at the outside edges and at the periphery of the circular hole of the plate to a high degree of accuracy. For the stress distribution in the unbuckled state, the stress distribution of the infinite plate with a circular hole under compression in one direction is taken. The integrations are carried out numerically using Gauss' method. Clamped and simply supported outer edges are considered. The critical load is given as a function of the ratio of the diameter of the central hole to the length of the square plate. In the case of clamped edges the critical load has been computed for both the fundamental and the secondary buckling mode, as it appears that buckling occurs more easily in the second mode than in the fundamental mode if the diameter ratio of the hole exceeds the value 0.34. The calculated values of the buckling load are compared with the results of experiments on Plexiglas specimens. The slope in a point of the plate for given load in the specimen has been measured by a scale telescope using a mirror device. From the load-slope curve the critical stress is determined by the Southwell-Donnell method. The critical loads obtained by calculation are slightly higher than the experimental values. The distribution of the curvature of the perforated plate in the buckled state, measured by optical means, agrees fairly well with that of the assumed deflection pattern. J. F. Besseling, Holland

61. Csonka, P., Elastic theory of the lining of double-walled insulated circular cylindrical shells under fluid pressure, *Acta Techn. Hung. Budapest* **8,** 3/4, 295–317, 1954.

Paper analyzes the forces and bending moments originated in the lining (inner shell) of double-walled underground structures where, between lining and mantle (outer shell), a gap is produced through shrinkage of the lining, and where the pressure of ground water, leaking through the outer shell, lifts the inner shell and presses it against the outer cylindrical mantle. The inner shell contacts the outer mantle either along a single generatrix or along a segment of the cylinder. The rigorous solution is given in a set of formulas. A numerical example shows the easy way to calculate practical problems. G. Sonntag, Germany

62. Shaw, F. S., Linear theories of shells, *Polyt. Inst. Brooklyn Rep.* no. 247, 150 pp., 1954.

A pedantic discussion of shell theory is presented in this report. Material covered is divided into four main sections: (a) Mathematical fundamentals, 53 pp.; (b) general discussion of deformation and equilibrium, 48 pp.; (c) exact linear theory, 36 pp.; and (d) approximate linear theory, 12 pp. The development of

the analysis adheres to the differential geometry approach, whereby conventional approximations are examined for their consequences wherever introduced.

In the linear theory, only the two leading terms in the Taylor expansion are retained, and normals to the undeformed shell midsurface are assumed to remain normal only at the midsurface after deformation. These conditions lead to the necessary consequence that all transverse strain components are identically zero throughout the shell wall. It is noted that these results would imply the unlikely condition that the transverse stress component does not vanish at the free surface and that this particular result should be replaced by the more obvious zero transverse normal stress condition, which corresponds to a generalized plane stress proposition. By virtue of the generalized plane stress proposition, it is shown that the exact linear theory would result in five linear differential equations in terms of displacement components; one equation of moment equilibrium being identically satisfied for any shape of shell. These results are illustrated by the case of shells of rotational symmetry.

When "order of magnitude" approximations are introduced, it is found that the afore-mentioned moment equilibrium condition is no longer satisfied, except for very special cases. Furthermore, transverse shear strains are no longer identically zero. It is suggested, however, that these inconsistencies are usually ignored in an approximate theory.

No application is included in this report, inasmuch as its purpose is stated to be only a "discussion of the theories of strength." It is the reviewer's belief that additional discussion of methods of solution and possible applications to shell problems would greatly enhance the value of this report. In particular, the lengthy mathematical preliminaries in part (a) probably could be shortened to make room for these topics. C. C. Wan, USA

63. Narduzzi, E. D., and Welter, G., High-pressure vessels subjected to static and dynamic loads, *Welding J.* **33,** 5, 230s–238s, May 1954.

Buckling Problems

(See also Rev. 60)

64. Bölcskei, E., Stability of rectilinear bars suspended at two points (in German), *Acta Techn. Hung. Budapest* **8,** 3/4, 243–256, 1954.

Paper represents a generalization of two papers by Csonka on the sidewise buckling of a supported beam. Reference should be made to Csonka's papers [see following review; also AMR **7,** Rev. 3527]. The two points of suspension of the beam are symmetric with respect to the midlength position and are equidistant from the ends. Since the distance from the end is arbitrary in the solution, it may be zero or half-length of beam as special cases. The solution is interesting theoretically and it has been adapted by the author for rapid application to practical cases. W. H. Hoppmann, II, USA

65. Csonka, P., Stability of straight beams suspended at one point (in German), *Acta Techn. Hung. Budapest* **8,** 3/4, 389–397, 1954.

In a previous paper [AMR **7,** Rev. 3527], author determined the characteristic load for the sidewise buckling of a beam supported from its end points. In the present paper he determines the buckling loads for a beam supported from its midpoint only. Reference should be made to a generalization by E. Bölcskei (see preceding review). W. H. Hoppmann, II, USA

66. Wittrick, W. H., Symmetrical buckling of right-angled isosceles triangular plates, *Aero. Quart.* **5,** part 2, 131–143, July 1954.

Buckling under combined compression and shear of right-angled isosceles triangular plates is considered. Boundary conditions included are: All edges clamped; all edges simply supported; perpendicular edges clamped, hypotenuse simply supported; perpendicular edges simply supported, hypotenuse clamped. Solutions are given in terms of series of exceptionally appropriate functions satisfying boundary conditions. Numerical values are presented for 16 combinations of compression and shear. It is shown that if the plate is subjected to shear only, the critical stress is considerably greater when the shear is tending to decrease the right angle than whan it is tending to increase the right angle. Interaction curves are drawn which author feels bring out essential features of the buckling behavior of oblique plates. S. Levy, USA

67. Nash, W. A., Buckling of thin cylindrical shells subject to hydrostatic pressure, *J. aero. Sci.* **21,** 5, 354–355, May 1954.

Paper treats briefly the problem of the instability of a thin cylindrical shell, either built-in or simply supported at its ends, under hydrostatic pressure. Approximate formulas are given for the (classical) critical pressure. A standard energy method is employed, the strain energy of the shell being approximated by an expression due to L. H. Donnell [*Trans. ASME* **56,** p. 795, 1934]. Some numerical results are given and comparison is made with results derived from formulas previously given.
H. G. Hopkins, USA

68. Okumura, A., An example of buckling problems of framed structure in space, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 59–64.

Paper gives an analysis of the buckling problem for cage-form cylindrical structures, loaded in compression. By considering a segment of the structure, the general differential equations and boundary conditions are derived. Instead of solving the differential equations as a whole, the columns parallel to the longitudinal axis of the cylindrical structure and the closing beam structure are treated separately. From the stiffness properties of the closing beam structure, expressions are derived for the inclination and the deflection of the column ends by unit shear and unit bending moment. Thus the problem is reduced to a buckling problem of a single column, perfectly clamped at its lower end and elastically clamped at its upper end. The buckling modes are investigated and the buckling load is calculated as a function of the stiffness parameters and the length-diameter ratio of the cylinder. The fundamental mode is of a rotational or irrotational type, depending on the structural dimensions. An approximate stability equation is given relating the unknown buckling load to a known buckling load belonging to neighboring structural dimensions. Approximate formulas for the buckling load derived from this equation give sufficient accuracy in an unexpected wide domain. J. F. Besseling, Holland

Joints and Joining Methods

(See also Rev. 99)

69. Mordfin, L., and Wilks, I. E., Tests of bonded and riveted sheet-stringer panels, *NACA TN* 3215, 45 pp., June 1954.

Panels were fabricated from 75S-T6 with a $3^1/_2$-in. stringer spacing to compare bonded with riveted construction. Compression panels were 18 in. × 15 in. and bending panels were $12^1/_2$ in.

× 4½ in. Bonded panels were made with I-stringers using Araldite Type I and Metlbond adhesives. Riveted panels were made with Z-stringers using $^{5}/_{32}$-in. 17S-T3 rivets and $1^{1}/_{8}$-in. pitch. Flat end compression tests showed that the sheets were stabilized better by bonded than by riveted stringers. A concentrated compressive load was introduced by extending the middle stringer beyond the sheet on one of the loaded ends. This test showed that riveted and bonded joints are about equal in spreading a concentrated load. Bending tests showed that either type of construction is strong enough for the kind of shear that accompanies bending. Further conclusions and observations were that both types were comparable in over-all strength, that spread of data was about the same for both, that cleavage need not always govern the strength of bonded panels, that bonded panels failed suddenly while riveted panels gave warning of impending failure, and that faulty bonding can be serious if not detectable. N. C. Costakos, USA

70. Rühle, H., Construction of statically indeterminate structures by postum joining of prefabricated reinforced-concrete elements (in German), *Beton u. Stahlbeton.* **49,** 2, 32–36, Feb. 1954.

Author shows how to determine moments in statically indeterminate structures formed by connecting, with concrete, prefabricated elements. He analyzes the effects of creep and shrinkage of the concrete in the prefabricated elements and in the connections. These effects should be taken into account, as different results are thus obtained from those derived with the usual methods of analysis which do not consider them.

E. Rathgeb, Argentina

71. Czechowicz, J., Comparison of the work of building wire nails of round and square cross section (in Polish), *Inżyn. Budown.* **11,** 2, 38–43, Feb. 1954.

The results are based only on the investigation of round and square nails whose diameter or length of one side is 4.6 mm. The investigation includes the analysis of four-nail, symmetrical joints, working in compression. As the basis of comparison, author analyzed the differences in cross sections, in weights, and in costs of the nails. The strength data include the loads carried at given slips and the maximum loads, as well as the data on parallel-to-grain strength of the wood used for the joints. Some characteristics have been calculated, namely the "efficiency" of the joint depending on the load carried, on the strength of the wood, and on the cross sections, weights, and costs both of square and round nails. The data have been given a detailed statistical treatment. As the number of joints tested in each series was small, Student's test has been used. On the whole, no significant difference was found between the two types of nails as to their "efficiency" with regard to cross sections, weights, and costs. In some cases the round nails showed better results than the square ones. From author's summary

Structures

(See also Revs. 68, 71)

72. Horne, M. R., A moment distribution method for the analysis and design of structures by the plastic theory, *Proc. Instn. civ. Engrs.* **3,** part 3, 1, 51–76, Apr. 1954.

In a very clear manner the author describes a new procedure of plastic (limit) analysis of beams and frames. The procedure used resembles superficially the well-known elastic moment distribution method. Actually, new rules for carry-over factors, and of central (midspan) hinge moments, are devised. Five well-chosen examples, solved in detail, illustrate the procedure; one of these deals with a continuous beam; the four others with planar frames. In one of these examples, the design of a structure to withstand several different combinations of loads is discussed. In another example, a building frame with uniformly distributed vertical loads, and lateral loads, is considered. As characteristic of the plastic methods of beam and frame analysis, no difficult mathematics is involved. The study of this paper is recommended to all interested in plastic analysis of structures

E. P. Popov, USA

73. Heilig, R., On the theory of rigid composite structures (in German), *Stahlbau* **22,** 4, 84–90, Apr. 1953.

Author presents approximate and exact theories on the effect of normal and shearing stresses in composite T-beams for the case of unequal heating. In T-beams composed of concrete slab on girder of steel (so-called slab-on-girder beam), the linear temperature distribution between slab and web will change in case of unequal heating, thus causing different longitudinal deformation of concrete slab and steel beam and internal stresses, resulting in warping of the entire cross section of the beam. Therefore, the usual theory of flexure is not applicable, because the deformations are caused not only by normal longitudinal stresses but also by longitudinal tangential shearing stresses, distributed over the total length of the beam.

Author derives formulas in the form of differential equations for the longitudinal and transverse deformations of such composite beams and for all kinds of stresses in such beams, as well as graphics for normal stresses, longitudinal shearing stresses, bending moments, and vertical shearing stresses for specified points along the length of beam. These graphics help to readily determine all the stresses in composite beams for unequal heating. The influence of prestressing and plastic deformations (creep and shrinkage) is not included. Numerous examples are included.

Reviewer considers this article a well-executed piece of theoretical research, important for experiments with composite beams with or without shear connectors. A meticulous thoroughness pervades the entire article, particularly in the mathematical handling of the subject. Unfortunately, notation and symbols are not sufficiently explained and make it difficult to understand the article. It would be of interest to apply these theories to the experiments conducted at University of Illinois by the Engineering Experiment Station in 1952 and to check the results.

J. B. Gabrys, USA

74. Ono, K., and Tanaka, H., The connection of elasticity equations in statically indeterminate rigid frames, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 321–326.

Authors apply matrix algebra to structural analysis in solving a planar rigid frame. Due to the fact the end moments should be related to the end rotations by a transformation tensor as the stress to the strain by a tensor of modulus of elasticity, authors arrive at a solution in matrix form. Reviewer believes similar results may be obtained by the method of slope deflection using matrix algebra. D. H. Cheng, USA

75. Foulkes, J., The minimum-weight design of structural frames, *Proc. roy. Soc. Lond.* (*A*) **223,** 1155, 482–494, May 1954.

Author uses the theory of plastic collapse under bending action to derive equations for the minimum weight of simple portal frames under vertical and horizontal loading. The virtual work approach is used and a geometrical analog is described to prove

a few general theorems. It is to be hoped that the method will be extended to multibay and multistory frames.

G. G. Meyerhof, Canada

76. Homberg, H., Contribution to grillage beam calculation (in German), *Stahlbau* **23,** 1, 4–12, Jan. 1954.

An accurate, a simplified, and an approximate solution are discussed. Accurate method is based on a type of frequency equation the solution of which yields results which can be used in analysis. Assumptions made are: No twisting resistance exists; moments of inertia are constant; there are similar connections at all places of contact between cross beams and longitudinal beams; and the structure is bisymmetrical. Load may be placed at any point on the structure. Procedure is outlined for approximate analysis which, in reviewer's opinion, is the main contribution of the paper. R. B. B. Moorman, USA

77. Kohler, K., Multistory frames with symmetrical structure, loaded by transverse forces (in German), *Stahlbau* **22,** 12, 274–276, Dec. 1953.

Author deals with the computation of a special multistory frame (tower type), consisting of two columns slightly inclined, connected by horizontal girders at arbitrary intervals. Applying theorem of Castigliano, author deduces a formula for successive determination of internal axial forces and bending moments (a recursion formula). This formula has an analogy in electrical circuits, substituting constants of frame structure by electrical resistance and axial forces by current. Measuring current in this electrical apparatus (multipole circuit) analog to frame action, we can then easily calculate the unknown axial forces.

Though deduced formula is not fit for numerical calculation of this type of frame, it enables us to experimentally determine the internal forces, using a multipole circuit. H. Beer, Austria

78. Palotás, L., Computation of gridworks (in Hungarian), Budapest, Közlekedési kiadó, 1953, 434 pp.

The book's aim is to describe methods of calculation which may be considered as practically proved. It is composed mainly of articles published by the author and his two assistants, J. Illéssy and L. Kollár, and has been extended to minute study of the international literature on the subject. The book has the character of a monograph but also tries to continue development of the gridwork calculations.

The first chapter explains the general description of the gridworks problem. Chap. 2 contains the basic problem: the different solutions of the continuous girder on elastic supports introducing a new solution for the beam on elastic supports by the method of displacements. Chap. 3 deals with the general computing methods of gridworks, with special references to the approximative methods of Leonhardt, paying no attention to the twisting resistance of the beams. Chap. 4 discusses gridworks stiffened by cross bracings and wind trusses and gives a minute discussion of the elastic cross bracings. Chap. 5 deals with the computation of gridworks and considers the twisting resistance of the main beams by an exact and an approximative method. The consideration of the twisting resistance differs absolutely from the methods customarily used. Chap. 6 shows a special method for the solution of the linear set of equations used in statics by guiding the mathematical steps with statical and kinematical considerations. Chap. 7 presents the influence lines of continuous beams on elastic supports in tabular and graphical form. The tables and graphs at the end of the book help the structural engineer to design gridworks.

G. de Kazinczy, Sweden

79. Negoro, S., On a method of solving torsion and bending problems of continuous panel structures. II, *Rep. Res. Inst. appl. Mech.* **2,** 8, 165–179, Dec. 1953.

A method of solution is presented for continuous panel structures under transverse forces, twisting and bending moments. In the first report, the panel structures treated are those with members perpendicular to each other. The method is now extended to structures whose members are not necessarily perpendicular to each other. C. T. Wang, USA

80. Flierl, K., Stiffening of a twisted open hollow structure, with an example of stiffening of miter gate (in German), *Mitt. Versuchsanstalt der Tech. Hochschule München,* H. 1, 63–79; München, R. Oldenbourg, 1953.

The elastic behavior of prismatic hollow bodies with one side face open, subject to a twisting moment around the main axis, is first studied under the assumption that the thickness of the walls is everywhere small as compared to the over-all dimensions of the body, and that the displacements, parallel to the main axis, of the two ends of the body are completely free. The open side face is supposed to lie on a plane parallel to the main axis and hence to have a rectangular shape, while no limitations are set on the shape of the cross section of the body. The stiffening of such bodies by means of a single diagonal beam on the open side face, of two diagonals, of a series of oblique beams connected to transverse struts, and finally by means of a rigid rectangular frame enclosing the open side face, is then studied. The statically indeterminate stresses in the stiffening elements are found, by use of the principle of virtual displacements, as a function of the applied twisting moment. Formulas are derived for the relative rotation of the two ends of the body and for the shear stresses generated by the stiffening elements in the walls of the body. An example of the application of the method is finally given, by calculating the stresses in the stiffening diagonals of a miter gate.

P. L. Romita, Italy

81. Moll, H., Prestressed concrete [Spannbeton], Stuttgart, Berliner Union, 1954, 272 pp., 271 figs. DM 48.

The German Patent Office expert for prestressed concrete wrote this book. He hence could use a collection of literature, patent manuals, etc., rarely available. The material is completed by reports, drawings, and photographs offered by engineers and builders of many countries.

The author does not discuss the theory and calculation of prestressed concrete. After a short report of its history and development, he describes the methods and implements for its manufacture, dividing the material into pretensioned and posttensioned structure. The German prestressing methods are completely treated, as well as those of other European countries, America, and Russia. In the following chapters one reads about the influence of rubbing at curved prestressed cables, about special methods to induce the stresses into the cables, wires, or into the concrete, and about the steel for prestressed structures; also about the use of nylon and glass for cables. The last part outlines the applications of prestressed concrete, describing the most important buildings, illustrated by photographs.

The book is remarkable for the author's objectivity on the various methods. It gives a complete view of the present state of the art. G. Brandes, Germany

82. Janney, J. R., Nature of bond in pre-tensioned prestressed concrete, *J. Amer. Concr. Inst.* **25,** 9, 717–736, May 1954.

Experimental studies were made of two types of bond stress in prestressed beams: (1) that due to release of wire pretension after casting, and (2) that due to flexure. Stress transfer from

wire to concrete was effected in 1 to 3 feet for wire diameters from 0.100 to 0.276 inches. Analysis and tests suggest that prestress transfer bond is due mainly to friction, slightly rusty wire having superior bond. Bond increase with higher quality concrete is probably due to greater ability to sustain radial pressures resulting from wire expansion upon pretension release. Embedment necessary to transfer stress increases moderately with wire diameter. Beams prestressed with clean wire failed in bond while those with rusty wire failed by wire fracture. Highest flexural bond stress occurs at center of beam with cracking and progresses to both ends of beam so that ordinary bond stress equation does not give accurate values. Length of steel available for flexural bond is reduced by greater part of prestress anchorage length. If bond stress is cause of beam failure, prestressed beam has greater ultimate load than unprestressed beam reinforced with same steel R. B. McCalley, Jr., USA

83. Gifford, F. W., The design of simply supported prestressed concrete beams for ultimate loads, *Proc. Instn. civ. Engrs.* **3,** part 3, 1, 125–143, Apr. 1954.

Paper ties closely with earlier article by same author [title source, part III, **2,** 3, 589–608, Dec. 1953]. There, design equations are developed in terms of the permissible concrete working stresses and certain beam factors, such as location of steel. Present paper develops corresponding ultimate load equations for rectangular beams and I-beams. The ratio of the ultimate moment equation to the working-load moment equation defines the factor of safety.

Variation of factor of safety with working steel stress and several other variables is presented by series of curves. Some experimental data are presented to indicate the usual range of several of the constants that appear in the ultimate moment equations. Author presents his method of analysis and design without making recommendations as to the appropriate design stresses.

Reviewer notes that curves for rectangular sections show factors of safety in the range of 1.6 to 1.9 for unbonded wire, and for bonded wire generally in the 1.8 to 2.2 or 2.3 range. Similarly, a typical flanged section shows a limiting factor of safety of 2.0. Reviewer considers this indicates more emphasis on ultimate strength and factor of safety (and less on working stresses) would be appropriate in the design of prestressed-concrete members.

P. M. Ferguson, USA

84. Young, D. R., and Hechtman, R. A., Shearing resistance of bolts partially embedded in concrete, *Trend Engng. Univ. Wash.* **6,** 2, 16–21, Apr. 1954.

The general effect of the amount of embedment, the bolt diameter, and the concrete strength upon the shearing capacity of bolts embedded in concrete was found. The importance of the edge distance of the bolt was also indicated, and this factor will be touched upon in future tests. One factor which was not covered by this preliminary investigation was the effect of reinforcing steel in the vicinity of the bolt. The tendency of some of these plain concrete specimens to be split around the bolts suggests that properly placed reinforcement might substantially increase the shearing resistance of embedded bolts.

From authors' summary

85. Macerata, S., Some aspects of prestressed concrete with particular reference to electrical transmission structures, *Trans. S. African Instn. civ. Engrs.* **4,** 2, 65–78, Feb. 1954.

The case for using prestressed reinforced concrete in the design of electric transmission masts and traction-supporting structures is presented. A study is made of the component materials and emphasis is laid on the importance of the original water/cement ratio of the concrete used. Partly from theoretical considerations, but mainly from empirical data, it is shown that only concrete obtained from a paste free from capillary water can eliminate the danger of the steel reinforcement corroding within the structure.

The principles of prestressed concrete are briefly reviewed. Ultimate stresses are more closely investigated and a method is suggested to enhance the normal ultimate strength of the concrete.

A test on a type of mast intended for railway electrification is described in detail. From the results obtained and from an analysis of the performance of the mast under test as well as from calculated stresses, the exceptional safety of prestressed-concrete structures is demonstrated and a suitable criterion for determining the failing load in prestressed-concrete design is advocated. The economical aspect is illustrated, giving sizes, calculated weights, and quantities of materials used, as well as proposed uses for seven different types of prestressed masts, ranging from low-voltage distribution and telegraph poles to 60-ft masts suitable for high-voltage transmission. From author's summary

86. Fonrobert, F., Basic aspects of wood construction [Grundzüge des Holzbaues im Hochbau], 6th ed., revised by Stoy, W., and Dröge, G., Berlin, Wilhelm Ernst & Sohn, 1953, xxiv + 276 pp., 280 figs., 10 tables. DM 15.

The sixth edition of this "guide for study and practice" was rewritten by an associate, Dr. W. Stoy, and student, Mr. G. Dröge, of the original author, the late Dr. F. Fonrobert.

The book was published to serve as an introduction for the inexperienced student in the field of wood construction; thus it discusses the basic aspects involved, especially in light of German practices and regulations. It does not discuss the basic theories, however, or their applications. Text is illustrated by fully detailed samples.

Special consideration is given to savings in materials, both lumber and steel, for jointing the lumber. The nail is given particular attention as an "underdeveloped" fastener, although the discussion does not include successful non-German nail developments, such as the Swedish rectangular fluted and the American threaded nails.

The book is a valuable introduction for a freshman course in wood construction in Europe, especially in Germany, since all aspects are discussed with reference to German standards.

Consisting of seven parts, the book can be divided into two sections. Section 1 covers fundamentals and fasteners (87 pp.); section 2 covers structural members and structures including built-up beams, plate girders, plain and built-up columns (157 pp.)

No reference is made to information gathered, e.g., in the United States, which makes this otherwise valuable book incomplete and even misleading, for instance, in the case of box columns. E. G. Stern, USA

87. Niles, A. S., and Newell, J. S., Airplane structures. Vol. I, 4th ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, xvi + 607 pp. $7.75.

This fourth edition of vol. I of "Airplane structures" by Alfred S. Niles and the late Joseph S. Newell is more than a mere revision; it actually represents a rewriting of the third edition.

Vol. I has long been regarded by teachers and practicing engineers as the classical textbook published in this country on the fundamentals of airplane stress analysis. The objective of the authors has always been to provide a textbook which emphasizes the basic principles of stress analysis and at the same time gives the student an acquaintance with the more commonly used

methods of analyzing practical airplane structures. The authors continue these objectives in the fourth edition, and the level of required student preparation remains the same. The volume is designed primarily for use in undergraduate courses in aeronautical engineering, and it is assumed that students will have had the usual college courses in calculus and a course in strength of materials. Although the applications in the book have been selected on the basis of importance to aeronautical engineers, they are equally applicable to many types of nonaeronautical structures, such as bridges, buildings, machines, and vehicles. The volume is, in fact, an elementary text on the general theory of structures with special emphasis on methods appropriate to the analysis of structures like aircraft, in which high strength-to-weight ratios are essential.

The most important change in the new edition is the increased emphasis on thin metal construction through improved coverage of incomplete-tension-field and constant-shear-flow webs, patterns of internal stress distribution, combined bending and torsion of shells, plate buckling, and local instability failures. Of the new additions to the book, perhaps the most important is the completely new chapter on the physical properties of structural materials. This chapter, which is especially well done, increases the value of the text tremendously for classroom use, since a coverage of structural materials and their relation to structural design are a necessity in an introductory course in airplane structures. Another important addition is the final chapter devoted to an introduction to statically indeterminate structures. This final chapter contains, with some revisions, a part of the first chapter in the second volume of airplane structures. Thus the fourth edition now includes an adequate introduction to statically indeterminate structures. The revision of the chapter on connections should also be mentioned. This chapter now includes an excellent discussion of modern methods of analyzing lap joints with applications to cemented, spot-welded, and riveted joints.

No significant deletions have been made except removal of the material applicable to wood wings and welded steel tube fuselages. As a result of the numerous additions and the few deletions, the fourth edition is appreciably longer (607 pp.) than the third (454 pp.).

The fourth edition represents the culmination of a 25-year era of collaboration between Niles and Newell, an era which was ended by the death of Prof. Newell in 1952. The numerous friends of Prof. Newell who knew of the many hours of writing and infinite attention to detail that he lavished upon the book prior to his death, look upon the fourth edition as a fitting memorial to this great man and beloved teacher.

R. L. Bisplinghoff, USA

88. Eggwertz, S., Calculation of stresses in a swept multicell cantilever box beam with ribs perpendicular to the spars and comparison with test results, *Flygtekn. Försöksanst. Medd. Rep.* 54, 43 pp., Mar. 1954.

Computations using energy methods are presented for comparison with experimental results on a 30° swept four-cell box beam which is clamped at the root. Several assumptions are used in the analysis for the bending stiffness of the wing ribs and for the stress distribution in the inner trapezoidal cover panels. It was found that the differing assumptions had little effect on the bending stresses in the spars. These stresses differed from experimental values by 10% or less. The difference between computed and measured shear stress was about 30%, which, author states, may result in part from experimental difficulty in measuring shear accurately. Author feels method presented is capable of high accuracy when structure is divided into a large number of elements. S. Levy, USA

89. Argyris, J. H., The open tube, *Aircr. Engng.* **26,** 302, 102–112, Apr. 1954.

A short critical historical survey of main developments in the theory of torsion of open, thin-walled cylindrical tubes—by Saint Venant (uniform twist), Timoshenko (nonuniform twist of I-beam), Wagner (generalization to arbitrary section by assumption of Saint Venant warping). Argyris and Dunne added to nonuniform torsion theory (constrained warping) refinement of shear strain corresponding, in Timoshenko I-beam theory, to shear deflection of flanges as beams. This is shown, by computation and confirming tests, to be significant for box beam minus sheet on one side, 7 × 20-in. section, 28-in. cantilever length. Axis of twist is curved.

Brief reference to torsional instability includes family of curves for buckling compressive stress of flat panel with two stringers, accounting for local buckling of stringer and plate as well as torsional buckling of stringer. J. N. Goodier, USA

90. Person, P., Stability and strength of an undercarriage radius rod, *Aircr. Engng.* **26,** 303, 154–156, May 1954.

91. Wilkinson, K. G., Progress in sailplane design, *J. roy. aero. Soc.* **58,** 523, 456–469, July 1954.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 71, 72, 133, 134, 135)

92. Good, R. C., Jr., New method of measuring elastic and plastic strains in a surface, *J. Franklin Inst.* **258,** 3, 237–240, Sept. 1954.

Note consists of $1^1/_2$ pages purporting to show how mean strains suffered by elements of distorted grid on meridian plane of an extrusion can be derived from measurements of grid node displacements. Reviewer is not convinced that certain of author's premises are correct. For instance, author states: "Many items are produced by extruding soft metals into symmetrical shapes. Their meridional planes usually exhibit plane strain during deformation. . . . Because plane strain exists when the points do not move perpendicular to that plane, we can use a billet split down the center to create that plane without affecting the process."

Reviewer believes that in the symmetrical extrusion of round billet into round rod, for example, although there is no movement of material across a meridian plane, there *is* strain perpendicular to that plane; in fact, circumferential strain rate of amount u/r, where u is radial velocity and r is radius to element considered. Author makes no mention of strain in this direction.

Author's method is doubtless valid for two-dimensional case, but reviewer would point out that, in the case of symmetrical three-dimensional steady-state problems (e.g., lubricated extrusion), strain rates are more easily and accurately determined by ascertaining velocities along streamlines of the flow and differentiating the components of these velocities with respect to the appropriate axes of symmetry. J. M. Alexander, England

93. Knopoff, L., On the dissipative viscoelastic constants of higher order, *J. acoust. Soc. Amer.* **26,** 2, 183–186, Mar. 1954.

A mathematical treatment is given for the stress-strain relationship which includes not only the stresses and strains but also derivatives of these quantities with time. A necessary, but not sufficient, condition is that the generalized ratio of the compressional and shear viscosities must be positive.

L. Nielsen, USA

94. Prager, W., Three-dimensional plastic flow under uniform stress, *Rev. Fac. Sci. Univ. Istanbul* **19,** 1, 23–27, Jan. 1954.

In view of the role that regions of uniform stress play in the theory of plane plastic flow, the most general velocity field that is possible under a uniform state of stress at the yield limit is investigated. Two cases are distinguished, according to whether all principal components of the stress deviation are different from zero (regular case) or not (degenerate case). The analytical description of the velocity field involves two arbitrary functions in the degenerate case but no such functions in the regular case.

From author's summary by R. Hill, England

95. Yamamoto, Y., A general theory on the plastic behavior of metals, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 93–96.

In this paper, a general stress-plastic strain law is introduced. It is a generalized form of that given by W. Prager, and the former contains the latter as a special case. Also, it is effective for material which shows the Bauschinger effect. As for fracture, author recognizes it as a sort of instability phenomenon which depends upon the property of the aeolotropic tensor.

In this theory, the aeolotropic tensor plays the most important role. From author's summary by H. Lin, USA

96. Narayanamurti, D., and Handa, B. K., Rheology of adhesives. Part I, *Kolloid Z.* **135,** 3, 140–150, Mar. 1954.

The flow behavior of two adhesives, casein-sodium hydroxide and resorcinol-formaldehyde, following their preparation, was studied. Two types of apparatus were used, a torsion viscometer and a penetroviscometer. To obtain the influence of adhesive-adherend interface several adherends, mostly wood, were used in appropriate part of apparatus. With casein glue, effects of variables such as component concentrations, chemical additives, stirring, and temperature were determined. Typical viscosity-time curve of casein system was not monotonic but showed, with increasing time, a rise to sharp peak at about two hours, a decline to a low value, then an increasing rise. Suggested explanation was, briefly, chain unfolding, chain degradation, and, finally, cross-linking and gel formation. B. M. Axilrod, USA

97. Lucas, G., and Lücke, K., Theory of hardening during the creep of metals (in German), *Z. angew. Phys.* **6,** 2, 64–70, Feb. 1954.

Authors develop pure exhaustion theory of creep in the particular case where the number of dislocation sources is an exponential function of activation energy at zero stress, and activation energy is a linear function of stress. The approximation of a sharp exhaustion front is used. This is shown to lead to a generalized parabolic strain-vs.-time relation, including the Andrade law with exponent $^1/_3$ as a special case with no special physical significance. The predicted exponent is not a constant but is proportional to the absolute temperature. Good agreement is found with the experiments of Carreker on the creep of platinum over a wide temperature range and with those of Lucas and Masing on the effect of sudden changes of temperature.

F. R. N. Nabarro, South Africa

98. Yokobori, T., The fatigue of metals from the standpoint of the nucleation theory, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 97–100.

Fatigue of metals was studied from the standpoint of the nucleation theory, which the author has already applied to static and creep failure. The meaning of the damage line and the endurance limit is interpreted and a theoretical criterion of fatigue failure is introduced. The characteristic features of fatigue, such as the influences of the combined stress state, the mean stress, and the temperature, seem to be well understood on the basis of this theory. From author's summary by H. Lin, USA

99. Fleischmann, M. L., Heat-treatments of welded structures for relief of residual stresses with particular reference to Type 347 stainless-steel weldments, *Trans. ASME* **76,** 4, 645–648, May 1954.

100. Merrill, E. W., Flow properties of some Buna-N solutions under high velocity gradients, *J. Colloid Sci.* **9, 2,** 132–140, Apr. 1954.

101. Vasilyev, L. I., On the correspondence between relaxation and rate characteristics in plastic extension, *Nat. Sci. Found.* tr-195, Feb. 1954; *Doklady Akad. Nauk SSSR* (*N.S.*) **92, 2,** 301–302, Sept. 1953.

Failure, Mechanics of Solid State

(See also Rev. 107)

102. Yokobori, T., The statistical aspect of fatigue fracture of metals, *Rep. Inst. Sci. Technol., Tokyo* **8,** 1, 5–12, 1954.

The previously reported data concerning two kinds of steel at three different stress ranges have been analyzed. The number of specimens used was about 70 to 100 per stress range. The analysis used the method of plotting for the survivorship function proposed by Gumbel and, independently, by Weibull. When fatigue fracture is regarded as a problem of stochastic process, the survivorship function p is approximately given by the form: $p = \exp(-NAS^{\gamma})$, where A and γ are constants. The apparent incubation interval of repeated cycles is considered to correspond to the actual incubation interval during which dislocations pile up at obstacles, and to the apparent incubation interval which the microcrack or crack nucleus takes in order to grow up to the macrocrack or lead to rupture of the whole specimen.

From author's summary

103. Plankenhorn, W. J., Effect of ceramic coatings on fatigue strength of metal, *J. Amer. ceram. Soc.* **37,** 6, 281–288, June 1954.

The fatigue limit and endurance life of ingot iron sheet samples were investigated with Krouse plate fatigue-testing machines of fixed deflection type. It has been shown that ceramic coatings and porcelain enamel increase the fatigue strength considerably. The thermal expansion coefficient for metal and coating being different, tensile stresses are set up at the metal surface after firing. The greater the differential expansion, the greater is the increase in fatigue strength. It has also been shown that the higher the firing temperature of ceramic coatings within the limits of 1500 and 1750 F, the greater is the resistance to fatigue failure. Besides prestressing, a redistribution of local stresses by the coating and its superficial solvent action on the metal, which makes the metal surface smoother, are suggested as possible reasons for increased fatigue strength. G. de Kazinczy, Sweden

104. Kennedy, A. P., A method for determining the "safe" life of an aircraft wing from fatigue test results, *J. roy. aero. Soc.* **58,** 521, 361–366, May 1954.

Purpose of the paper is to suggest an alternative to the arbitrary scatter factor which is used to convert typical fatigue test results to a statistical minimum. It is assumed that fatigue test results can

be represented by a log-normal distribution, and statistical methods applicable to small samples are used to determine the probability that a specimen can withstand a particular number of cycles.

Since it is not possible to eliminate completely the probability of failure by fatigue, the criterion used is that one failure is acceptable in a given length of time. By statistics of small samples, a minimum life can be determined with the chosen confidence from the test results available.

Since failure can initiate at any one of a number of places, the total probability of failure must be considered. The effect of renewing a part of the structure and the effect of type of structure are also discussed.

Examples facilitate understanding the methods proposed.

Marshall Holt, USA

105. Robertson, T. S., Propagation of brittle fracture in steel, *J. Iron Steel Inst. Lond.* **175,** part 4, 361–374, Dec. 1953.

This excellent paper describes a new type of notched-bar test to evaluate the brittleness of metals. In this test a specimen is used in which there is a crack, and a stress transverse to the direction of propagation is applied. The crack is arrested because it propagates into material of increasing toughness, made so by increasing the temperature along the length of the specimen. Speed of propagation of the cracks was measured and determined to be 6000 ft/sec near the notch and about 1500 ft/sec near the crack arrestment.

The results of these tests give critical stress values which are of the order of those observed in cases of service failure. The ductile arrest temperatures are in the same range as the service failure temperatures. Apparently this is one of the first tests which allow correlation of stress and temperature to determine catastrophic failure. The test is only moderately complicated. The Robertson test should receive much notice in material test laboratories.

A. D. Schwope, USA

106. Wada, E., Non-Newtonian viscosity of dilute high polymer solution, Parts I, II and III, *J. sci. Res. Inst. Tokyo* **47,** 149–171, Dec. 1953.

Material Test Techniques

(See Revs. 104, 120)

Mechanical Properties of Specific Materials

(See also Revs. 86, 87, 99, 106, 122, 239, 254)

107. British Iron and Steel Research Association, edited by, Physical constants of some commercial steels at elevated temperatures, London, Butterworths Scientific Publications, Ltd., 1953, x + 38 pp. $3.50.

This useful compilation summarizes in tabular or graphical forms determinations made at the National Physical Laboratory in the years preceding and following World War II. The determinations were made in pure iron and 22 steels, including carbon steels, low-alloy steels, and high-alloy steels, selected as typical compositions in use in 1936.

Measured properties included specific and total heats between 50 and 1200 C, coefficients of thermal expansion up to 1100 C, electrical resistivities between 0 and 1300 C, and thermal conductivities between 0 and 350 C. Derived properties include mean coefficients of expansion, densities at elevated temperatures, and thermal diffusivities.

Appendix 1 presents the results of electrical resistivity and thermal conductivity determinations of Armco iron and several modern high-temperature steels. Appendixes 2 and 3 outline the experimental procedures and give details of the mathematical treatments.

The compilation is of interest to metallurgists and engineers concerned with the heat-treatment of steels or with service applications involving elevated temperatures.

G. V. Smith, USA

108. Anonymous, Literature survey of high-strength steels. Prepared by Subcommittee on Research on High-Strength Steels, Materials Div. PVRC, *Welding J.* **33,** 5, 251s–256s, May 1954.

109. Ronay, B., and Clautice, W. E., Evaluation of superheater materials for high-temperature steam, *Welding J.* **33,** 4, 199s–206s, Apr. 1954.

110. Margen, P. H., High-temperature steam pipes. Properties of steels and basis of design, *Engineering* **177,** 4602, 457–462, Apr. 1954.

111. Forslind, E., Lattice dynamics of ice and a case of diffuse x-ray scattering (Thesis for the doctor's degree), Proc. Swedish Cem. Concr. Res. Inst., Stockholm, 42 pp., 1954.

From the experimentally determined constants of elasticity (Jona and Scherrer, 1952), the symmetry properties and the cell dimensions (Megaw, 1934; Orvston and Lonsdale, 1948) of ice crystals, author determines the intermolecular forces for ice or, more exactly, the forces between the oxygen ions. The influence of the hydrogen ions on these forces is looked upon solely as depending on their ability to form hydrogen bonds. From another point of view, the water molecules retain their individuality in the ice lattice and so the oxygen ions represent the water molecule.

Author uses the method of Begbie and Born, 1947. The wave velocities along different axes are determined as functions of the wave number $2\pi/\lambda$. To make experimental control possible, author calculates the effect of the atomic thermal motion on a beam of x rays passing through the crystal. The thermal scattering of ice does not contain the ordinary radial rays from the central point in the Laue diagram on the photographic plate, but is like, not a six-radiate, but a six-pointed star with the corners at the twelve nearest Laue spots.

The paper closes with a first approach to a theoretical explanation of this fact. The ultimate aim is to contribute to the elucidation of the atomic or molecular processes responsible for the plastic behavior of fresh and hardened concrete. There are practically no misprints in the paper and no mistakes.

O. H. Faxén, Sweden

112. Aichinger, K., A simple device for the determination of water content in cement slurry (in German), *Zement-Kalk-Gips* **7,** 43, 50–52, Feb. 1954.

The present treatise deals with the questions of using a simple device—curve consistency recorder as per Wandser—for the determination of the water content in cement slurry.

The main points to be mentioned are: (1) All examined raw meals present identical curves. (2) These are rectilinear for a range of the water content of cement slurries of 30 to 45%. The proper slurry susceptible of pumping is strictly limited, roughly between 41° and 45° as per Wandser. (3) The position of the straight lines on the flow-sheet water content/consistency varies according to the nature and the origin of the slurry and is a characteristic feature for each factory. (4) The device is noteworthy for its easy handling as well as for its rapid and safe functioning.

From author's summary

113. Vorreiter, L., Change of dimensions in wood due to moisture and temperature (in German), *ZVDI* **96**, 4, 103–104, Feb. 1954.

114. Clinebell, Betty Jo, Engineering developments of rubber—July, 1952-June, 1953, *Mech. Engng., N. Y.* **76**, 5, 414–420, May 1954.

115. Hensky, W., Roll neck bearings and other machine elements made of molded synthetic resin compounds (in German), *Stahl u. Eisen* **74**, 9, 552–560, Apr. 1954.

116. Catsiff, E., and Tobolsky, A. V., Relation between stress-relaxation studies and dynamic properties of polyisobutylene, *J. appl. Phys.* **25**, 2, 145–152, Feb. 1954.

Experimental results on stress-relaxation modulus $E_r(t)$ and complex dynamic modulus $E'(\omega) + iE''(\omega)$ of polyisobutylene are now available in the literature. To cover the entire time scale, the effect of changing the temperature of measurement is assumed to be equivalent to a linear change of the time scale. According to the general theory of linear viscoelastic behavior, the functions E_r, E', and E'' can each be computed from any one of them. This is qualitatively correct. The data on E' in the transition region can be represented by the Gauss error integral form of equation used by Bischoff, Catsiff, and Tobolsky for E_r of several polymers. The "wedge-box" distribution function proposed by Tobolsky is also compared with the experimental data and shows a reasonably good agreement with experimental results over the entire time scale. From authors' summary

117. Meredith, R., The torsional rigidity of textile fibres, *J. text. Inst. Trans.* **45**, 7, T489–T503, July 1954.

The resistance to twisting of single fibers of 34 textile materials has been measured by the torsion-pendulum method at 20 C and 65% relative humidity. Preliminary experiments investigated the influence of tension, damping, and period of oscillation. The modulus of rigidity G was calculated, after shape factors for the fiber cross sections had been determined (in some cases by means of soap film and the membrane analogy), assuming the applicability of isotropic elastic formulas. The results are compared with values of a tensile modulus E previously reported [title source, **36**, p. T107, 1945]. The ratio E/G is taken as a rough measure of the anisotropy of the fiber (examples: E/G = 20 for Fortisan, 6 for nylon, 3 for cotton).

A. D. Topping, USA

118. Wood, G. C., and Chamberlain, N. H., The relaxation of stretched animal fibers. Part I. An apparatus for the determination of relaxation curves, *J. text. Inst. Trans.* **45**, 2, T147–T161, Feb. 1954.

An account is given of the measurement of the relaxation of tension in stretched fibers. The apparatus described enables one to obtain, in addition to the long-term relaxation curve, a continuous record of tension during stretching of the material and the early stages of relaxation. It thus extends the time range over which observations can be made to lower values than has hitherto been possible. From authors' summary

119. Cox, D. R., Some statistical aspects of mixing and blending, *J. text. Inst. Trans.* **45**, 2, T113–T122, Feb. 1954.

A theoretical approach to the study of irregularities in slivers and yarns arising from the uneven mixing of fibers of different types. The paper is mainly concerned with mixing by doubling in the drawing operation. Statistical details are given in separate sections. From author's summary

120. Kumanin, I. B., and Ljass, A. M., Foundry core binding materials [Kernbinderwerkstoffe], Berlin, Verlag Technik, 1953, 256 pp., 52 figs., 6 tables. DM 28.

Book is a translation from the original Russian. It introduces the specialist in foundry practice to the Russian advances in the field of binding materials for foundry cores, particularly their synthesis, analysis, and manufacture.

First part of book deals with classification of core binding materials, the classification of cores, and the standard recipe for cores. The second part deals with the properties and uses of core binders, and the third part with the testing procedures for core binders.

This book may be considered as one of the most significant contributions to its field. D. Kececioglu, USA

Mechanics of Forming and Cutting

(See also Revs. 92, 302)

121. Sachs, G., Fundamentals of the working of metals, New York, Interscience Publishers, Inc.; London, Pergamon Press, Ltd., 1954, viii + 158 pp. $4.75.

The main portion of the book consists of three parts as follows: Discussion of metal properties influencing ductility and flow resistance; the types of failures encountered in metalworking; and the classification and grouping of the basic metalworking processes according to the state of stress involved. A final chapter treats combinations of the basic processes and continuous methods of fabrication.

Properties influencing ductility and flow resistance that are discussed include temperature, strain rate, chemical composition, phase change, precipitation, and grain structure. The basic types of failure considered are fracture due to insufficient ductility, necking due to insufficient strain hardening, buckling under compression due to excessive slenderness, and drawing failures due to the deformation of too large a volume for the size of the section across which the maximum force must be transmitted. The basic types of metal-working processes are considered from the point of view of the following classification of stress states: direct compression, direct tension, indirect compression, bending, contour-forming, and shearing.

This small book should be of considerable value to those engaged in the hot and cold working of metals, since it relates commonly observed difficulties to the basic concepts of materials, mechanics, and geometry. M. C. Shaw, USA

122. Rose, J. W., Lowenstein, P. L., Bishop, S. M., et al., How to work—tantalum and columbium, zirconium, and beryllium, *Amer. Machinist* **98**, 8, 188–208, Apr. 1954. Special Report no. 359.

123. Sachs, F., New Russian concept of cutting tools, *Amer. Machinist* **98**, 8, 170–171, Apr. 1954.

124. Clark, N., Jr., and Aloisio, J. P., Ultrasonic machine tool for cutting hard materials, *Tool Engr.* **32**, 4, 77–80, Apr. 1954.

125. Anonymous, Cool tip . . . not chip, with CO_2, *Amer. Machinist* **98**, 4, 130–136, Feb. 1954.

Paper describes a new English technique which at last applies coolant through lathe-tool shank, with reservoir under carbide tip and orifices aimed at work, not chips. The result is doubled or tripled cutting speeds.

In contrast to previous methods, the CO_2 is jetted through an orifice in the tool shank, from a reservoir bored under the tool tip. Thus the CO_2 first cools the bit, then the work, but not the chip. The CO_2 is refrigerated before application, so a higher percentage of solid CO_2 is formed in the jetted spray. Pressures about 200 psi above the corresponding vapor pressure of the cooled CO_2 prevents premature expansion so the CO_2 snow is formed only at the point where it is required. Ed.

126. **Weilenmann, R., The influence of cutting-speed variations on the service life of cutting tools** (in German), *Werkstatt u. Betrieb* **87**, 8, 401–403, Aug. 1954.

Mathematical analysis of the cutting-speed variations at tool tip due to vibrations. Component of relative motion between tool and workpiece in direction of cutting speed is considered and represented in graphical form. For self-excited vibrations the increase in speed can equal the cutting speed.

A. O. Schmidt, USA

127. **Krumme, W., The universal adjustment of test diagrams for precision spiral bevel gear cutting machines** (in German), *Werkstatt u. Betrieb* **87**, 5, 217–219, May 1954.

128. **Dismuke, S. E., Robot-run tools machine "hot" materials at Oak Ridge,** *Amer. Machinist* **98**, 8, 161–165, Apr. 1954.

A remotely controlled machine shop has been developed at the Oak Ridge National Laboratory as a part of the program concerned with the effect of nuclear radiation on the properties of solids. Here it is described in detail.

From author's summary

129. **Clark, S. K., The punching of medium carbon steel,** ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-35, 13 pp.

Effect of clearance between punch and die is investigated experimentally. For the range of clearances considered there is a significant decrease in work done by punch as the clearance increases.

Force-penetration records were obtained both for very low punch velocities and, using an autographic recorder, for more normal punch velocities. It is found that for the higher punch velocities the maximum punch force is appreciably lower than that measured in the slow speed tests. Author attributes this to thermal effects.

Making a number of simplifying assumptions, a semiempirical formula for punch force is obtained and the result compared with experimental data. F. Ellis, England

130. **Thweatt, H. D., How to choose hydraulic presses for metal forming operations,** *Amer. Machinist* **98**, 7, 116–126, Mar. 1954.

131. **Sims, R. B., The calculation of roll force and torque in hot rolling mills,** *Instn. mech. Engrs. Proc.* **168**, 6, 191–200, 1954.

Author derives equations to be used by mill designers, starting from Orowan's condition for plastic deformation and von Kármán's equation of equilibrium. The dependability of the yield strength of the rolled material on the current strain and strain rate (under condition of sticking friction) leads to the use of a "mean y. s."

Experiments with pure lead, rolled dry at room temperature, and Swedish measurements on mild steel at 1000–1200 C are shown. They agree satisfactorily with the proposed calculating method.

Although the equations suppose plane deformation, i.e., apply to material with a high width-thickness ratio, author expects their accuracy to be sufficient for engineering practice, even when rolling blooms and billets. Reviewer is inclined to ask further conformation by statistical research with different materials and dimensions in practical mills. (See also next review.)

G. de Witte, Holland

132. **Stewartson, R., Measurement and analysis of rolling loads in a large hot plate mill,** *Instn. mech. Engrs. Proc.* **168**, 6, 201–208, 1954.

Instruments have been constructed between screw and top bearing chocks of a heavy plate mill to attempt the measurement of nonuniform applied loads.

Load indications during the rolling of a varied program for plates are analyzed and compared with three roll-load formulas. That due to Sims seems to give the best agreement, whereas the other formulas show discrepancies often exceeding 50%. For reductions less than 10%, all three formulas show similar trends, giving values in general very much lower than those obtained with the instruments.

Although the instruments have proved satisfactory for short trials, certain features will be modified in models which are now being designed with a view to more permanent installation.

From author's summary

Pages 209–214 of title source give communications about the paper of Sims (see preceding review) and paper under review. They deal mainly with the choice of assumptions and the interpretations of the scatter in the results.

G. de Witte, Holland

133. **Yamada, Y., On the application of the theory of plasticity to hardness test and wire drawing,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 231–236.

Author considers slip-line fields for plane-strain indentation by a cylinder and plane-strain drawing through a die with circular entry for the range of reductions where the slip-line field intersects the axis of symmetry in a single point. No velocity boundary conditions are considered. J. F. W. Bishop, Scotland

134. **Yamanouchi, H., and Hayashi, I., Drawing force of rod through die,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 237–240.

Paper gives an approximate stress solution for drawing through a rough conical die. The shearing stress in the axial direction is assumed to obey a power law normal to the axis.

Corrections for "change of direction of flow" at entry and exit are taken from Korber and Eichinger. Apart from this consideration, velocities are not considered. J. F. W. Bishop, Scotland

135. **Kakuzen, M., Two-dimensional profile of drawing die and extruding nozzle by plasticity theory,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 241–244.

Author makes various assumptions about stresses in drawing and extrusion with rough dies and shows that if the coefficient of friction is constant the die geometry is determined. He concludes that this design corresponds to "uniform flow" conditions. J. F. W. Bishop, Scotland

136. **Wright, J. P., Non-cyclindrical contours—how you can grind them,** *Amer. Machinist* **98**, 10, 137–156, May 1954. Special Report no. 362.

Principles and current techniques of contour grinding are

given. Also included are latest applications, such as the tri-lobe contour for drive shafts and couplings to replace conventional splines or keys. From author's summary

137. McCracken, W. L., Ultrasonics and industrial cleaning, *Tool Engr.* **32,** 4, 66–68, Apr. 1954.

Hydraulics; Cavitation; Transport

(See also Revs. 39, 40, 167, 206, 219, 296)

138. Daugherty, R. L., and Ingersoll, A. C., Fluid mechanics with engineering applications, new 5th ed., New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, xiii + 472 pp. $7.

Book contains a preface, a list of notations, twenty chapters, four appendixes, answers to problems, and an index. Authors indicate in the preface that the title of this fifth edition was changed from "Hydraulics" to "Fluid mechanics . . . in order to emphasize the fact that the treatment is not confined to water or even liquids but is applicable to all fluids, including vapors and gases. Also, it is intended to indicate that, so far as possible with our present knowledge, the equations are based upon rational principles and that less dependence is placed upon purely empirical equations." Reviewer thinks that this effort in using the results of analysis is very commendable. At long last, mechanical, chemical, and civil engineers are taught to use the results of over fifty years of effort on the part of aeronautical engineers, workers in applied mechanics and in applied mathematics, which were devoted to clarifying fluid mechanics by systematic analytical and experimental means. It is the more disturbing to see the confusion which exists in notation. If only to help the student, a unified notation should be adopted in hydraulics, fluid mechanics, and aerodynamics.

The properties of fluids (including vapors and gases), the concept of pressure and methods of pressure measurements, together with instrumentation, and the hydrostatic force on areas (including dams, ships, submerged bodies) are discussed in the first three chapters. The fourth chapter deals with the kinematics of fluid flow. It introduces the concepts of laminar and turbulent flows, the continuity equation, and the "flow net" (i.e., the concept of potential and streamlines). The dynamics of fluid flow is treated in the fifth chapter. Kinetic, potential, and internal energies are introduced, the "flow work" defined, and the energy equations for liquids and for gases are given. The momentum equation is derived, the pressure head introduced, and the hydraulic and energy gradients explained. Linear and angular accelerations are prescribed and the forced and free vortexes introduced. Finally, cavitation is explained. The sixth chapter discusses dimensional analysis; the seventh, flow measurements such as the pitot tube, orifices, venturi, et al., and also weirs for open channels. The effects of compressibility are also discussed. Chaps. 8 and 9 are devoted to the presentation of flows through pipes. Chaps. 10 and 11 deal with uniform and nonuniform flows in open channels. Chap. 12 treats unsteady flows. Chap. 13 deals with forces on immersed bodies. Dynamic force and momentum are discussed in chap. 14, which is also the introductory chapter to rotating machinery. Similarity laws and factors for turbomachines are the subject matter of chap. 15. Impulse turbines, reaction turbines, centrifugal and axial-flow pumps, and fluid couplings and torque converters are treated in the next four chapters. In the last chapter, some of the basic equations of hydrodynamics are derived.

The first appendix gives dimensions and units, the second treats the velocity of pressure wave, the third contains cast-iron pipe dimensions, and the fourth those of steel and wrought iron.

A great number of problems, some with answers, are included in the text. Also, numerous references are given for pertinent additional literature.

The book gives the impression that it was written for civil-engineering students. Reviewer thinks, however, that it might be an excellent book for a first course in fluid mechanics for any engineering curriculum.

The book is well written, excellently organized, and nicely produced. T. P. Torda, USA

139. McLachlan, N. W., On a nonlinear differential equation in hydraulics, *Proc. Symp. appl. Math.*, vol. V, "Wave motion and vibration theory," New York, Toronto, London, McGraw-Hill Book Co., Inc., 49–61, 1954.

Author treats the equation

$$\ddot{u} + 2\kappa|u|\dot{u} + au = d \qquad (a, \kappa > 0, d \geqq 0)$$

which arises in various "square damping" problems. The one mentioned by the author is that of water flow in a hydroelectric system having a surge tank. He concludes that u always tends to d/a as t tends to infinity. He sketches the trajectories in the phase plane by the method of isoclines in three cases. For κ small he solves the equation by the method of Kryloff-Bogoliuboff.

The equation

$$\ddot{y} + 2\kappa y\dot{y} + ay = 0 \qquad (a, \kappa > 0)$$

is then discussed. This equation may be easily integrated once to get its phase-plane equation, which is graphed. Its time-dependent solution is gotten for y small by a perturbation development.

Courtesy of Mathematical Reviews E. Pinney, USA

140. Plesset, M. S., and Perry, B., On the application of free streamline theory to cavity flows, "Mémoires sur la mécaniques des fluides," *Publ. sci. tech. Min. Air, Paris,* 251–261, 1954.

After reviewing some known models for plane cavity flows with cavity underpressure coefficient ("cavitation number") Q and a new model due to Roshko, the authors turn to the axially symmetric case. Experimental evidence is presented which supports the rule of thumb, proposed by Reichardt, and Plesset and Shaffer [AMR **1,** Rev. 1499], for estimating cavity C_D for axially symmetric flows from known pressure distributions for plane flows. Exceptions for cones with vortex angles $2\beta < 90°$, as predicted by A. H. Armstrong, are noted.

G. Birkhoff, USA

141. Zarantonello, E. H., Parallel cavity flows past a plate, *J. Math. pures appl.* (9) **33,** 1, 29–80, Jan.-Mar. 1954.

It is known that an obstacle placed in a uniform stream of an ideal fluid does not determine a unique steady irrotational flow if the fluid is allowed to cavitate. There are two aspects of this indeterminacy: a number of topologically different flow configurations can occur, and for a given configuration more than one flow may be possible. The author sets for himself the problem of finding all the configurations which are possible when the flow is plane and the obstacle is a flat plate. The main assumptions made are that the flow not involve a second sheet of the flow plane and that there be no infinite velocities. These conditions unfortunately exclude at the outset several attractive and useful configurations (the re-entrant jet, for example, is disallowed for the former reason, and the finite trailing cavity for the latter). In conclusion, the author finds that under the conditions laid down there are only nine configurations; in seven the plate is parallel to the stream and circulation is present; the eighth is the

standard Kirchhoff flow with the plate arbitrarily inclined; and the last is the Kirchhoff flow with an added cavity in front of the plate.

Courtesy of Mathematical Reviews J. B. Serrin, USA

142. **Shal'nev, K. K., Cavitation of edge profiles of blade tips** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **14,** 131–141, 2 plates, 1953.

Author describes instrumental and visual results of series of experiments on tip profiles for the blades of axial flow pumps or turbines. Cavitation was of two types—in the tip clearance itself and in the wake of this clearance. A square-ended tip is liable to both types, but the former may be eliminated by rounding off the leading edge. It was found impossible to eliminate clearance wake cavitation, but its onset was delayed by giving the walls of the clearance an angle of divergence. Angles larger than two degrees reintroduced cavitation in the clearance itself. Zero angle of divergence is recommended in practice, since even the two-degree angle increased the liability to cavitation on any imperfections in the surface of the casing wall.

Semiempirical criteria are deduced for tip profile design, and their effectiveness in these experiments is examined.

Reviewer suspects that these results, obtained for flow between two stationary walls, may not be directly applicable to flow between walls having a high relative velocity, as in practice.

A. H. Armstrong, England

143. **Einstein, H. A., and Sibul, O., Open channel flow of water-air mixtures,** *Trans. Amer. geophys. Un.* **35,** 2, 235–242, Apr. 1954.

Paper deals with the problem of predicting the water surface in the pit of an impulse turbine when the jet has been wholly or partially diverted to the discharge.

The direct action of impinging jets causes a large amount of air to enter the water in the form of bubbles, which remain in suspension by fluid turbulence. The air bubbles are released when the turbulence of the flow has died down. Authors admit that, in such a case, the air concentration along vertical paths follows the law of suspension.

Authors examine the influence of the air on the back-water curves. They assume that the air-water mixture moves as a frictionless fluid through a channel with rectangular cross section. The very small air bubbles, uniformly distributed along vertical paths (in contrast with the distribution admitted before), have a velocity in the direction of the flow equal to that of the surrounding water. With these assumptions, applying the momentum equation to an infinitesimal stream element, authors find a relationship between the depth d, the volume ratio of water content to water-air mixture ρ, and the velocity V of the mixture. In this relationship the Froude number is a parameter and has the following expression: $F_0 = V_0/(gd_0)$, where g is the gravity acceleration, and V_0, d_0, respectively, the velocity and the depth of the flow at zero air content. In this way the existence of a critical depth of the flow is ascertained, i.e., the depth corresponding to the greatest air concentration.

Experiments, conducted in a rather crude way, show that the measured elevations, outside of the pit, are in good agreement with theoretical computations. Authors suggest the possibility of determining the backwater curves from model tests through knowledge of the average air concentration in the water and of the depth d_0 of the flow in consecutive sections.

Reviewer believes that the data presented are not yet sufficient for evaluating the advantages of this method, considering the known difficulties encountered in measuring the average concentrations.

A. Russo-Spena, Italy

144. **Agroskin, I. I., Computation of the velocity formula factor** (in Russian), *Gidrotekh. Stroit.* **22,** 10, 44–45, Oct. 1953.

Author introduced in 1949 an expression for the Chezy formula factor $c = 1/n + 17.72 \log R$, where n is coefficient of roughness, R hydraulic radius. Same expression can be transformed into exponential form $c = 1/n \cdot R^x$, where $x = \log(1 + 17.72\, n \log R)/\log R$. Author compares the x values with a Pavlovsky formula $x = 2.5\, n - 0.13 - 0.75R^{1/2}(n^{1/2} - 0.10)$. Both formulas show close coincidence at $n = 0.025$ for earth canals.

S. Kolupaila, USA

145. **Zhelezniak, I. A., Computation of maximum discharge taking into account reservoir regulation** (in Russian), *Gidrotekh. Stroit.* **22,** 9, 21–25, Sept. 1953.

Two diagrams simplify computation of decrease of the flood maximum due to regulation of a reservoir, filled to the spillway crest, assuming triangular and trapezoidal form of the flood hydrograph. Approximative solution is suitable for small reservoirs.

S. Kolupaila, USA

146. **Anonymous, Surges in southern outfall sewer and flow conditions in State Fairgrounds (Western Parkway) pumping plant, Louisville, Kentucky. Hydraulic model investigation,** *Wwys. Exp. Sta. tech. Memo.* no. 2–367, 42 pp., 31 tables, 40 plates, June 1954.

Model studies were considered necessary to solve certain problems in connection with the design of pumping plants to dispose of runoff during high river stages. Studies of a 1:32 scale model of a typical plant and sewer line to investigate surges, and of a 1:16 scale model of a pumping plant to provide information on its performance, are described in detail. Water-hammer effects were found to be eliminated by an open sump at the pump and certain relationships were established between sump and manhole sizes and height of surge. Of greater general interest is the analytical method presented for the determination of sewers, showing satisfactory agreement with model results.

W. DeLapp, USA

147. **Anonymous, Submergible-type Tainter gate for spillway at Cheatham lock and dam, Cumberland River, Tennessee,** *Wwys. Exp. Sta. tech. Memo.* no. 2–281, 22 pp., 15 tables, 34 plates, Apr. 1954.

Tests were conducted on a 1:36-scale model of the submergible-type Tainter gate proposed for use on the spillway at Cheatham Lock and Dam. These tests were concerned with the determination of the hydraulic characteristics of the gate as demonstrated by the force required to raise and lower the gate under all possible operating conditions. The tests showed that the gate as originally designed was unsatisfactory because of its instability and the uplift forces and high downpull forces exerted on it. As the test gate was raised, pressure conditions over the gate were such as to cause it to oscillate. Downpull forces were as high as 650 kips or about twice those considered allowable.

Revisions to the crest and over-all shape of the gate, together with proper venting, eliminated all uplift forces tending to float the gate and reduced downpull forces to within allowable limits. The tendency of the gate to oscillate also was eliminated by the design developed from the model tests. Results of tests on the 1:36-scale model were confirmed by later tests on a 1:10-scale model.

The actual design of gate adopted for construction in the prototype was a semisubmergible type; flow is to be passed over this gate up to a head of 7 ft, after which the gate will be raised and all flow will pass under it. This type gate was not tested in the model except for stilling basin tests that were conducted, using a schematic reproduction of the final-type gate. These tests indi-

cated that a horizontal apron, 64 ft in length at elevation 345, and a 9-ft-high end sill would be most effective in stilling flow passing either over or under the gate. From summary

148. Toch, A., Discharge characteristics of Tainter gates, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 295, 20 pp., Oct. 1953.

Author presents in dimensionless form the results of model tests on the discharge of Tainter gates with level floors for both submerged and free jet flow. The coefficient of discharge is presented graphically for various values of relative opening heights and relative trunnion heights. The effect of the lip angle on the coefficient of contraction for free efflux is also presented. Dimensionless head loss curves for submerged efflux are given. Author states that general methods of analysis are applicable to other types of gates. W. M. Owen, USA

Incompressible Flow: Laminar; Viscous

(See also Revs. 138, 141, 143, 172, 177, 184, 185, 199, 201, 245, 295)

149. Nuttall, H., Flow of a viscous incompressible fluid: expressions for a uniform triangular duct, *Engineering* **178,** 4623, 298–300, Sept. 1954.

Solutions are given for the volume rate of flow of a viscous, laminar, steady, and incompressible flow in a uniform duct whose cross section is an isosceles triangle. The solutions are also said to extend to compressible flows when the pressure gradient is not too large. Flow coefficients are tabulated for triangles of base-to-height ratio ranging from $^2/_3$ to 3.46666, there being 33 entries in this table. Exact and approximate methods for solving the flow equation are discussed briefly.

R A. Burton, USA

150. Okabe, J., An approximate calculation of the flow of a viscous fluid past a body having a flat end, *Rep. Res. Inst. appl. Mech. Kyushu Univ.* **3,** 9, 45–50, Apr. 1954.

The flow of a viscous incompressible fluid over, and behind, a semi-infinite rectangular body is calculated by the "modified" Oseen approximation. In the limiting case of a flat plate, the velocity distribution along the axis of the wake has been compared with the calculation of Goldstein [*Proc. roy. Soc. Lond.* (*A*) **142,** 545–560, 1933]. As expected, the discrepancy is large.

Y. H. Kuo, USA

151. Vladimirsky, S., Generalized velocity potential and its hydrodynamic application (in French) "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris,* 413–416, 1954.

The generalized velocity potential $\varphi + [-\epsilon(x, y)]^{1/2}\psi$, introduced by D. Riabouchinsky [*C.R. Acad. Sci. Paris* **222,** 426–428, 1946], is described and the velocity components of two-dimensional rotational flow are given. To approximate a viscous flow round a circular cylinder, the function $\epsilon(x, y)$ is chosen to yield a flow with velocity zero on the circle and homogeneous at infinity.

The potential, stream-function, and velocity components are calculated and a figure of the streamlines and the equipotential lines is added to the text. E. M. de Jager, Holland

152. Thom, A., Treatment of the stagnation point in arithmetical methods, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2807, 10 pp., May 1951, published 1954.

For certain flow problems, use of log $1/q$ as a variable in the relaxation method is suitable. The variable tends to infinity at a stagnation point and the difference equation is no longer adequate in this region. Methods are given to overcome this difficulty. Correction terms for the network points are given and various applications are indicated. G. V. R. Rao, USA

153. Milne-Thomson, L. M., Stokes' complex theorem (in French), "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris,* 233–239, 1954.

Author derives Stokes' theorem, the kinetic energy of a fluid, and the mass flow in complex form. Use is also made of complex variables in finding expressions for the surface of Joukowsky profile and for the center of pressure. H. H. Hilton, USA

154. Shul'gin, D. F., Flow around a compound profile of varying permeability (in Russian), *Prikl. Mat. Mekh.* **17,** 3, 285–292, May/June 1953.

S. A. Chaplígin in his article "Schematic theory of slotted air-foil" [see S. A. Chaplígin, "Collected works," **II,** 431–471, Moscow-Leningrad, 1948] discussed two-dimensional flow of an incompressible fluid around a slotted airfoil with any number of slots. In the article mentioned above, S.A. Chaplígin obtained a formula

$$dW/dz = V_0(\cos\beta - i\sin\beta)([(z - x_1)\ldots\ldots(z - x_n)]/[(z - a_1)\ldots\ldots(z - a_n)])^{1/2}$$

where W is a characteristic function, V_0 velocity of flow at infinity, β angle of attack, and a_1x_1, a_2z_2, . . . a_nx_n are segments on the real axes. The author applies Chaplígin's formula to the case of the profile of an airfoil, which consists of a sequence of penetrable and nonpenetrable segments alternating with one another.

T. Riabokin, USA

155. Slezkin, N. A., and Shustov, S. N., On the stability of particles suspended in a laminar flow (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **96,** 5, 933–936, June 1954. (English translation by M. D. Friedman is on file with Scientific Translations Division, Library of Congress.)

Differential equations are derived describing the motion of spherical particles in laminar flows having rectilinear and parabolic velocity distributions. A side force on the particles due to circulation is included in the formulation. In each case, expressions are developed for a critical Reynolds number above which the particle motion is unstable. These critical Reynolds numbers depend on the shape of the particles, the square of the ratio of the characteristic dimension of the particle to that of the flow, and, for the parabolic distribution, on the ratio of the initial distance of the particles from the center line of the flow to the characteristic dimension of the flow. G. C. Wallick, USA

Compressible Flow, Gas Dynamics

(See also Revs. 138, 184, 185, 201, 204, 243, 244, 266)

156. Shapiro, A. H., The dynamics and thermodynamics of compressible fluid flow. Vol. II, New York, The Ronald Press Co., 1954, xi + 651–1185. $16 (2 vol. set, $30)

The second volume of the set is a worthy continuation of the first one. It consists of the continuation of part 5 of the first volume and of three more parts. Also, a comprehensive index of both volumes is given at the end of vol. 2.

Axially symmetric supersonic flow, supersonic flow past wing of finite span, and hypersonic flow are treated in the second half of part 5. Part 6 discusses mixed flows. The hodograph

method for mixed subsonic-supersonic flow, the transonic flow, and drag and lift at transonic speeds are treated. Part 7 is an up-to-date treatment of unsteady motion in one dimension. The unsteady wave motion of small amplitude, the unsteady one-dimensional continuous flow, and unsteady one-dimensional shock waves are discussed and their analysis is given as far as possible. The eighth part contains the flow of real gases with viscosity and heat conductivity. The laminar and turbulent boundary layers and boundary layers in tubes and in the presence of shock waves are treated.

The inclusion of more numerous references in the second volume will be particularly helpful for workers using the book. The author is to be congratulated for his work. The execution of both volumes is very good. As has been stated already, when the first volume was reviewed, the work will be very useful for the student, the practicing engineer, and also for the research worker.

T. P. Torda, USA

157. **Hartley, D. E., The pressure rise with subsonic Mach number on fuselages and nacelles,** *J. roy. aero. Soc.* **58,** 524, 567–569, Aug. 1954.

The pressure coefficient on a body in compressible flow below critical Mach number is established to be $\beta^{-1/2}$ times the pressure coefficient on the same body in incompressible flow [$\beta = (1 - M_0^2)^{1/2}$]. The Prandtl-Glauert method is used to determine the velocity increment in the compressible flow in terms of that on an analogous body in incompressible flow. Kuchemann's approximation to exact solutions is used to express the dependence of the velocity increment on fineness ratio, and the usual linearized pressure coefficient relation is employed. The result compares favorably with RAE and NACA test data on ellipsoids of revolution and waisted bodies.

H. M. Voss, USA

158. **Longhorn, A. L., Subsonic compressible flow past bluff bodies,** *Aero. Quart.* **5,** part 2, 144–162, July 1954.

Author derives the velocity potential for a prolate spheroid immersed in a perfect fluid and, specifically, the correction factor to be applied to the incompressible velocity solution at the surface. The Janzen-Rayleigh method is employed to the order of the Mach number squared, thus limiting the results to low Mach numbers. Only the first three terms of an infinite series expressing the coefficient of M^2 are tabulated, but the author does show that eventually the terms of the series decrease exponentially. Curves are presented as a function of the body axis ratio which illustrate the transition from slender body to Rayleigh's sphere results. Summary plots and tables permit interpolating the correction coefficient for any axis ratio.

J. R. Baron, USA

159. **Oswatitsch, K., The drag increase at high subsonic speeds,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2716, 16 pp., Oct. 1947, published 1954.

The drag increase beyond the critical Mach number is calculated by modifying only the supersonic part of the von Kármán-Tsien pressure distribution on a profile. This is possible when the supersonic regions are not too large. The formula giving the modified pressure distribution is derived very roughly. It may give only one of the main effects appearing when supersonic speeds occur in the flow, and may be changed and calculated more exactly later.

For the calculation of the drag increase, the formula is adequate and the agreement of theory and experiment in all examples calculated is very good. Within the approximation of the theory, the lift coefficient is unchanged. Calculations of the center of pressure are not made.

From author's summary by M. H. Bertram, USA

160. **Thompson, J. S., A simple method of computing C_D from wake traverses at high-subsonic speeds,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2914, 12 pp., Dec. 1944, published 1954.

This is a republication of *RAE Rep. Aero* 2005 (Dec. 1944). For the benefit of those who are unfamiliar with the earlier publication, it is pointed out that Mr. Thompson has constructed nomograms which simplify the computing of the drag integrand (C_D') or the F factor (which converts the integrated total head loss into the drag coefficient) from the wake traverse static pressure and local head loss. There is also a discussion which shows that the accuracy of the charts is compatible with the over-all accuracies involved in the use of the wake survey method.

E. E. Covert, USA

161. **Lukasiewicz, J., Stewart, J. D., and Laberge, J. G., Half-model tests of two small aspect ratio delta wings at subsonic, transonic and supersonic speeds,** *Nat. aero. Establ. Canad.* LR-92, 40 pp., Jan. 1954.

The aerodynamic characteristics of two small-aspect-ratio ($A = 2.12$ and 2.77) delta wings were determined at Mach numbers from 0.6 to 2.5 and Reynolds numbers (based on m.a.c.) from 1.0 to 1.6 million in the 10-in. and 30-in. wind tunnels, using half models mounted on the tunnel wall.

Since the half models were embedded in a relatively thick tunnel-wall boundary layer in the 30-in. tunnel, tests were carried out with the model displaced from the tunnel wall at subsonic and supersonic speeds to determine boundary-layer effects. In general, the boundary layer reduced the lift curve slope and increased the static margin at subsonic Mach numbers, but had a negligible effect at supersonic speeds.

The primary effect of increasing the aspect ratio was to increase the lift curve slope. The minimum drag was unaffected at subsonic speeds but increased with increasing aspect ratio at supersonic Mach numbers. The static margin was unaffected by aspect ratio.

From authors' summary

162. **Truitt, R. M., Solution of the general two-dimensional subsonic compressible flow by a new physical transformation,** "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris,* 397–405, 1954.

Reviewer believes author is wrong in stating he obtained new compressibility correction, and one that included nonlinear effects of potential flow equations. Author's results apply only to linearized small perturbation flows and are, therefore, the same as previously used by reviewer (*NACA RM* no. A7B10, May 1947).

Author's argument is only applicable to small perturbations, because velocity of sound must be assumed constant in his development. Since local velocity of sound varies directly with first power of perturbation velocity, author's ad hoc development is at best a first-order approximation for slender profiles. Consideration of second-order nonlinear terms by reviewer [AMR **5,** Rev. 1805] shows that use of local Mach number in Prandtl-Glauert rule overestimates the velocity increase for compressible flow over convex profiles. For thick profiles the overestimate is more in error than the underestimate obtained when using the free-stream Mach number in Prandtl-Glauert rule.

E. V. Laitone, USA

163. **Neumark, S., Critical Mach numbers for thin untapered swept wings at zero incidence,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2821, 74 pp., Nov. 1949, published 1954.

This report is a continuation of AMR **6,** Rev. 1691, and AMR **7,** Rev. 1864, and enables both the velocity distribution and critical Mach number to be determined for untapered swept wings of

large and medium aspect ratio. The calculations are based on the linearized theory, and earlier results have been extended to cover a wide class of symmetrical airfoil section profiles.

The conditions for the occurrence of sonic velocity at any point of the wing are examined in detail. Since this critical condition is not reached simultaneously on the entire wing surface, we have to deal with a critical range of Mach numbers. At the lower critical Mach number, sonic conditions are reached at a single point (often, but not always, in the central kink). At the upper critical Mach number, sonic conditions have spread over the entire wing span.

Using the Prandtl-Glauert law, critical Mach numbers are calculated first for infinite straight wings with various profiles and thickness ratios and then for infinite yawed or sheared wings. The velocity distributions (and hence the supervelocities) for a swept wing are found, using the methods in the afore-mentioned reports. It is shown that for wings of aspect ratios greater than 2, considerable parts of both semiwings are regular regions with isobars running almost parallel to the wing edges and with velocity distributions almost the same as for infinite sheared wings. For such swept wings the velocity field in the kink is practically identical with that in the corresponding portion of an infinite swept wing, while the velocity field in the tip region is practically identical with that at the tip of a semi-infinite sheared wing.

The upper critical Mach number is that of the regular region of the wing and is the same as for an infinite swept wing. The upper critical Mach number is the same for two wings of the same sweep (back or forward) and thickness, but varies with the profile. This Mach number equals sec (ϕ) where ϕ is the angle of sweep for an infinitely thin wing but is less than sec (ϕ) for a swing of finite thickness.

The lower critical Mach number may occur at the kink (for airfoils with fore and aft symmetry), at the regular section (for airfoils without fore and aft symmetry at small angles of sweep back), or at the tip (for highly swept wings). It is always less than unity, being higher the higher the angle of sweep.

The velocity distributions, isobars, and critical Mach numbers for various profiles are given in a number of tables and graphs and their practical meaning for the designer is discussed. It is shown that the choice of airfoil profile should be influenced by the angle of sweep.

Reviewer notes that Fig. 34 should refer to profile R and Fig. 37 to profile B. A. W. Babister, Scotland

164. Muggia, A., Graphical methods for studying two-dimensional supersonic flows (in Italian), *Aerotecnica* **34,** 2, 72–82, Apr. 1954.

In plane whose polar coordinates are $1/\rho V$, θ, characteristics are parallel to Mach lines in physical plane. This allows two improvements to graphical method: (a) in tracing speed, (b) in exactness, for Mach lines chords are closely parallel to "hodograph" characteristics chords. In second part of paper, graphical method for problems involving shock waves is presented, similar to K. Oswatitsch's method [AMR **6**, Rev. 2579].

G. Moretti, Argentina

165. Heinz, C., Supersonic flow about slowly oscillating bodies of revolution (in German), "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris*, 119–127, 1954.

Consider a body performing slow small harmonic pitching oscillations with small mean angle of attack. For corresponding irrotational flow, Sauer [AMR **4**, Rev. 78] splits potential function into steady axisymmetric part, quasi-steady part analogous to cross flow in term in steady flow at angle of attack, and nonsteady part. Time and azimuth independent factors of all three are expressed as integrals of singularity distributions. Boundary conditions yield integral equations for first derivatives of distribution functions. Author expands certain factors of integrands in series of Jacobi polynomials and integrates repeatedly by parts to replace integrals by infinite series in successive integrals of Abel transforms (special convolutions) of first derivatives. Series are truncated according to author's accuracy criterion to obtain linear ordinary differential equations for highest order integrals of Abel transforms, from which distribution functions can be obtained by numerical integration. Results are to be applied in general formulas for pressure, normal and damping force, pitching and damping moment coefficients. J. H. Giese, USA

166. Naylor, D., The simple wave in rotational gas flow, *J. rational Mech. Analysis* **3,** 4, 415–433, 1954.

Paper deals with steady, adiabatic, and isoenergetic rotational flows of a perfect gas. It studies degenerate hodograph flows in the plane and axially symmetric cases by the application of the Legendre transformation to the Crocco stream functions. It gives a new (though less general) derivation of Martin's [*J. Math. Phys.* **29,** 263–281, 1951] basic result that the lines along which the velocity vector is a constant in the nondegenerate plane case must be concurrent or parallel straight lines. These two admissible classes of flows, already treated at considerable length by Prim [AMR **6,** Rev. 570], are then rediscovered. The treatment of the axially symmetric case rederives a subclass of the spatial flows studied by Neményi and Prim [op. cit.].

R. C. Prim, III, USA

167. Laitone, E. V., Developments in gas dynamics by the hydraulic analogy, "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris*, 203–217, 1954.

Author describes the restrictions with regard to water depth and model size which are met in using hydraulic analogs for determining compressible flows. Further, he points out a method to eliminate unwanted reflections and choking effects, to measure water depths by means of electrical resistance probes, and he compares experimental results with those of small perturbation theory.

J. H. van de Stadt, Holland

168. Runyan, H. L., and Watkins, C. E., Considerations on the effect of wind-tunnel walls on oscillating air forces for two-dimensional subsonic compressible flow, *NACA Rep.* 1150, 7 pp., 1953.

Supersedes article reviewed in AMR **5,** Rev. 1473.

169. Glass, I. I., Martin, W., and Patterson, G. N., A theoretical and experimental study of the shock tube, *Univ. Toronto Inst. Aerophys. Rep.* no. 2, 281 pp., Nov. 1953.

This is a combined textbook and detailed progress report on the shock tube. In addition to a tour through the relevant one-dimensional gas dynamical theory, the reader is given an account of experimental arrangements, followed by a wealth of schlieren records (in the x, t-plane) of wave generation as a function of initial pressure ratio, and assorted interaction phenomena. Examples are shock-wave attenuation, shock-shock interactions, shock-contact surface interaction, shock-screen interaction.

Attempts at theoretical prediction of shock attenuation by estimating boundary-layer growth as a parallel-streamline, nonsteady Rayleigh flow are unsuccessful.

Reviewer's remarks: A more plausible approach to the shock-tube boundary layer is the ordinary semi-infinite wall, steady boundary-layer theory applied with the wall moving faster than the free stream. For incompressible flow this was given by the reviewer in 1949, using the von Kármán integral relation (lec-

tures on "Viscous fluid flow," The Johns Hopkins University), and pursued for arbitrary fixed wall velocity by Glassman ("Proposition" accompanying Ph.D. disertation, Johns Hopkins Univ., 1950). The full compressible field solution has been published by Hollyer ["A study of attenuation in the shock tube," Univ. Mich., July 1953]. S. Corrsin, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 243, 245, 263)

170. Crabtree, L. F., The compressible laminar boundary layer on a yawed infinite wing, *Aero. Quart.* **5,** part 2, 85–100, July 1954.

For a yawed infinite wing, when the flow is incompressible, the boundary-layer equations show that the chordwise flow field can be determined independently of spanwise flow. This has been called the "independence principle." In a compressible flow field, however, since the fluid density and viscosity depend on total velocity and since these quantities appear both in equations of chordwise and spanwise flow, the equations can no longer be separated and, hence, the independence principle ceases to exist.

Author succeeds in showing that, for the case of heat-insulated wall, of Prandtl number unity, and with linear dependence between viscosity and temperature, introduction of Illingworth-Stewartson transformation reduces the boundary-layer equations to a form closely resembling those of incompressible flow—differing from the latter only by the presence of an additional term in the unit factor to pressure-gradient term of the equation of motion for chordwise flow. Since this term is usually small ($<0.2M_s^2$, where M_s denotes Mach number of spanwise component), it can be considered as an expansion parameter and a successive approximation procedure accordingly set up, so that at each stage the independence principle can again be applied.

An investigation of the flow corresponding to stagnation region of the related incompressible case is carried out to first-order approximation. Equations are solved by using Adams' numerical method, and results tabulated and plotted. It is seen that the effects of yaw on chordwise flow profile and boundary-layer thickness are appreciable, while those on spanwise component are small.

Complicatedness of the approach is admitted, and use of momentum method for approximate study of boundary-layer development is discussed. H. S. Tan, USA

171. Wundt, H., Theoretical investigations of the laminar boundary layer, problem I—Growth of the laminar boundary layer of yawed cylinders starting from rest, Final Rep., Contract no. AF 61 (514)-627-C, Air Res. Develop. Command, USAF, European Office, 42 pp., Apr. 1954.

Using the boundary-layer approximation, the "principle of independence," and the (time) expansion parameter of Blasius, the author obtains a series solution and gives a tabulation of the "universal coefficient functions." He applies these to the example of an impulsively started circular cylinder in yaw.

No mention is made of the steady-state calculations on yawed cylinders published in the United States (Jones, Sears, Rott, etc.). S. Corrsin, USA

172. Görtler, H., Theoretical investigations of the laminar boundary layer, problem II—Decay of swirl in an axially symmetrical jet, far from the orifice, Final Rep., Contract no. AF 61 (514)-627-C, Air Res. Develop. Command, USAF, European Office, 40 pp., Mar. 1954.

By linearizing the equations of motion of the laminar jet flow with respect to the swirl component—the latter being weak, relative to the velocity component in the direction of the axis—we find ourselves confronted by an eigenvalue problem of an ordinary differential equation of second order. Although this differential equation appears somewhat complicated at first sight, a suitable change of variables enables us to reduce it to the differential equation of Legendre functions. Thus it becomes possible to find a complete and exact solution of the eigenvalue problem. The theory shows that the swirl in a free jet always decreases according to a higher power of the inverse distance from the orifice rather than the velocity component of the jet in the direction of the axis.

Author also points out that if the exchange coefficient in a swirling turbulent jet should turn out to be reasonably constant across a section, these results can be used. In nonswirling jets this is true only near the axis.

From author's summary by S. Corrsin, USA

173. Dhawan, S., Direct measurements of skin friction, *NACA Rep.* 1121, 20 pp., 1953.

Supersedes article reviewed in AMR **5,** Rev. 1838.

174. Klebanoff, P. S., Characteristics of turbulence in a boundary layer with zero pressure gradient, *NACA TN* 3178, 56 pp., July 1954.

Measurements were made with hot-wire anemometer across one section of boundary layer on a smooth flat plate. Besides mean velocity distribution, the following properties of the turbulence were measured: intensity, cross-velocity components, turbulent shear stress, probability density and flattening factor of fluctuation in longitudinal direction, spectra of turbulent energy and shear stress, and various velocity derivatives. Most important part of paper is analysis and discussion of intermittency of boundary layer, defined as the fluctuation of free edge of the layer. Author concludes that this edge has a sharp outline constantly changing in irregular manner; that the average wave length of this edge is roughly twice the boundary-layer thickness; and that the position of the edge is approximated closely by a Gaussian distribution. Allied to this phenomenon is the observation that the probability density of the longitudinal fluctuation is very close to Gaussian in the region unaffected by intermittency.

Author discusses turbulent energy balance across boundary layer and shows that approximately 85% of the total dissipation (viscous and turbulent) takes place within the laminar sublayer. A rather surprising conclusion is that there is a flow of energy toward the wall because of the action of pressure forces. In the outer region of the boundary layer the velocity gradient influence is not felt, and it is shown that existing theories for energy spectrum for isotropic turbulence do apply to the results. Close to the wall, nonisotropy is significant and the spectra are much different.

Reviewer finds paper easy to read, clearly written, and containing much new information. He recommends it to all engineers engaged in work in the boundary-layer field.

W. D. Baines, Canada

175. Rouse, H., Measurement of velocity and pressure fluctuations in the turbulent flow of air and water, "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris,* 283–287, 1954.

Paper is brief review of work done at Iowa Institute of Hydraulic Research on pitot tube for measurement of three turbulent velocity components and turbulent pressure fluctuations in water. Design is evolved from study of pressure distribution about cylinder with hemispherical head at angles of yaw. Author shows

that for angles $< 15°$, readings from tip opening and four openings at angle 47° from center line can be combined to give the four components. After brief discussion of construction problems, author reviews properties of two experimental instruments.

W. D. Baines, Canada

176. Ogura, Y., and Miyakoda, K., Some remarks on the "Turbulent element model" of the isotropic turbulence, *J. meteor. Soc. of Japan* (2) **31,** 6, 206–218, June 1953.

Using Fourier analysis, the authors first give the relation between the energy spectrum of a turbulent velocity and the spectrum of some types of average of this velocity. Using this result they compare two models of isotropic turbulence: "Turbulenz-element" from C. F. Weizsacker, and "Turbulon" of E. Inoue [AMR **5,** Rev. 3011], and the way by which the $-5/3$ power law for the energy spectrum could be derived from these models.

J. Kampé de Fériet, France

Aerodynamics of Flight; Wind Forces

(See also Revs. 22, 25, 35, 88, 154, 163, 200, 201, 202)

177. Hancock, G. J., The design of thin finite wings in incompressible flow, *Aero. Quart.* **5,** part 2, 119–130, July 1954.

Relation between downwash and vortex distribution, usually known as Biot and Savart's law, is derived by aid of Green's theorem. Relation is used for determination of the shape of central surface (camber and twist) when wing planform as well as pressure distribution is given. Pressure distributions considered are zero at leading edge. Author remarks that, if such pressure distributions are realized at cruising speed, low values of the drag may also be expected for neighboring flight conditions. Three examples have been worked out, two of which refer to a rectangular wing of aspect ratio 2 and one to a cropped delta with 90° apex.

A. I. van de Vooren, Holland

178. Piland, R. O., The zero-lift drag of 60° delta-wing-body combination (AGARD model 2) obtained from free-flight tests between Mach numbers of 0.8 and 1.7, *NACA TN* 3081, 11 pp., Apr. 1954.

The zero-lift drag of a 60° delta-wing-body combination (designated AGARD model 2) has been determined by free-flight tests of two models between Mach numbers of 0.8 and 1.7. These Mach numbers correspond to Reynolds numbers, based on body length, of 4×10^6 and 12×10^6, respectively. An estimate of the drag of the configuration was made by summing the estimates of the drag of the various components. The agreement between measured and estimated drag is good.

From author's summary

179. Duquenne, R., and Grandjean, C., Determination of the effect of thickness of symmetrical wings upon the zero lift with aid of electrical analog (in French), *C. R. Acad. Sci. Paris* **238,** 15, 1564–1566, Apr. 1954.

180. Berggren, R. E., and Graham, D. J., Effects of leading-edge radius and maximum thickness-chord ratio on the variation with Mach number of the aerodynamic characteristics of several thin NACA airfoil sections, *NACA TN* 3172, 65 pp., Apr. 1954.

A wind-tunnel investigation has been made to determine the effects of leading-edge radius and maximum thickness-chord ratio on the variation with Mach number of the aerodynamic characteristics of several thin symmetrical NACA 4-digit-series airfoil sections. The Mach number range of the investigation was from 0.3 to approximately 0.9, and the corresponding Reynolds number range from approximately 1×10^6 to 2×10^6.

The variations with Mach number of the lift, drag, and pitching moment for a 4%-chord-thick airfoil section are not significantly affected by a change of leading-edge radius from 0.18 to 0.53% of the chord. A similar conclusion can be drawn for a leading-edge-radius variation from 0.10 to 0.40% chord on a 6% chord-thick section.

Progressive improvement of the variation of lift-curve slope with Mach number, the lift and drag-divergence characteristics, and the maximum section lift characteristics at Mach numbers above 0.6 results from reduction of the maximum thickness-chord ratio from 10 to 4%. Section pitching-moment characteristics are not greatly affected by variation of the maximum thickness-chord ratio.

From authors' summary

181. Edwards, R. H., Leading-edge separation from delta wings, *J. aero. Sci.* **21,** 2, 134–135, Feb. 1954.

182. Riebe, J. M., and Naeseth, R. L., Aerodynamic characteristics of a refined deep-step planing-tail flying-boat hull with various forebody and afterbody shapes, *NACA Rep.* 1144, 19 pp., 1953.

Supersedes article reviewed in AMR **6,** Rev. 600.

183. Örnberg, T., A note on the flow around delta wings, *Roy. Inst. Technol. Div. Aero., Stockholm, KTH-Aero TN* 38, 32 pp., Feb. 1954.

In order to find reasons for some irregularities in delta wing force and moment curves as measured in wind tunnels, some investigations have been made of the flow on and around wings of this type and its effect on the pressure distributions. The flow on and around wings with various sweep angles and profile thicknesses has been investigated at low speeds (the boundary-layer flow on the suction side also at supersonic speeds). Low-speed pressure distributions have been measured on and above the suction side of these wings.

The low-speed investigations show that edge vortexes are produced by separation at highly swept leading edges and have a marked effect on the surface pressure distribution. The cores of these vortexes have also been localized and measured at different angles of incidence. The supersonic tests suggest that the vortexes still exist provided that the leading edge is well behind the nose Mach cone.

The behavior of these vortexes under different conditions appears to explain the afore-mentioned irregularities in force and moment curves.

From author's summary

184. Scholz, N., Cascade flow investigations, part I. Vortex flow in axial blade rows (in German), *VDI-Forschungsheft* (B) **20,** 442, 5–24, 1954.

First part of report presents extended measurements carried out on axial blade rows with axial inflow and outlet angles of 16.5 and 25° and with hub-tip ratios between 0.4 and 0.8. Investigation was particularly devoted to vortex flow behind blade rows and, further, to pressure distributions over blade surface. Occurrence of flow stagnation cores at hub downstream of the blades was found to be in agreement with Bammert-Kläuken's theory [AMR **4,** Rev. 1319]. Pressure distributions show strong minimum region on suction face at about 60% chord length, where a curvature discontinuity occurs on blade profile. Good agreement was found between measured radial pressure distributions and theoretical values from simple radial equilibrium condition.

P. Schwaar, France

185. **Scholz, N., Cascade flow investigations, part II. Computation method for the design of cascade-blade profiles** (in German), *VDI-Forschungsheft* (B) **20,** 442, 25–48, 1954.

In this second part (see preceding review) the inverse cascade theory problem has been solved under various pitch and stagger conditions. For given inlet and outlet flow conditions, the blade profile and the pressure distribution over it are to be found if a certain vortex and source distribution has been set along the blade chord. The change in the pressure distribution and of outlet angle produced by a variation of inlet flow direction can also be calculated. Special simplifications are possible only if the cascades are slightly staggered, and the effect of compressibility was accounted for by means of linearized flow theories. Some numerical examples dealing with decelerating and accelerating cascades are included to show how the method is applied.

P. Schwaar, France

186. **Graham, E. W., Lagerstrom, P. A., Licher, R. M., and Beane, B. J., A preliminary theoretical investigation of the effects of propeller slipstream on wing lift,** *Douglas Aircr. Co. Rep.* SM-14991, 75 pp., Nov. 1953.

The effect of propeller slipstream on wing lift is studied. Theoretical approaches based on lifting-line theory are reviewed and a new method based on "slender-body theory" is introduced. Weissinger's lifting-surface theory is used to show that slender-body theory assumptions are more realistic than those of lifting-line theory in most cases. All theoretical methods assume incompressible flow and replace propeller by actuator disk. Comparison with experimental data is made. Certain discrepancies show need for experiments specifically designed to give data on isolated components of the problem.

From authors' summary by H. Mirels, USA

187. **Stone, R. W., Jr., Estimation of the maximum angle of sideslip for determination of vertical-tail loads in rolling maneuvers,** *NACA Rep.* 1136, 12 pp., 1953.

Supersedes article reviewed in AMR **5,** Rev. 3194.

188. **Carpentier, J., and Vernet, J. F., Frequency response of several airplanes** (in French), *Publ. sci. tech. Min. Air, Paris,* no. 386, 104 pp., 2 diag., 1953.

Longitudinal and transverse response of several aircraft to a harmonic excitation of the controls is considered. Sixty-two frequency-response curves are presented; they were obtained by calculation (on the assumption of complete rigidity of the structure) from the linear equilibrium equations of small displacements, and are graphed in terms of transfer functions relating the rigid-body velocities and increments in pitch, roll, and yaw to all the control rotations.

The aircraft considered include a four-engined survey aircraft (SE1010), a two-engined light transport (MS703) for longitudinal response; and a four-engined transport (SE2010), a light monoplane (SE2310), a D. H. Vampire, and the SE1010 for transverse response. Effects of altitude, speed, flight-path inclination, and pitching moment derivative m_u are studied for the longitudinal case. Transverse-response curves include some showing effects of variation of the aerodynamic derivatives.

The application of the response curves to stability determinations of motions in the phugoid, pitch, yaw, and the spiral is discussed. Simple criteria for control stability (stick fixed and free) are suggested in terms of the transfer functions of the aircraft and the control. Brief mention is made of the extension to automatic control, tracking, and guidance.

Authors note that flutter oscillations are excluded from the analysis. Reviewer notes that higher excitation frequencies recorded on some graphs are within the range where aeroelastic deformations cannot be neglected.

J. D. C. Crisp, Australia

189. **Bethwaite, C. F., Note on the development of a trailing-edge flap as a stall-detector,** *Coll. Aero. Cranfield Rep.* no. 75, 15 pp., Sept. 1953.

190. **Brehaus, W. O., and Segel, L., Notes on aircraft dynamic stability testing and analysis techniques,** *Cornell aero. Lab. Rep.* CAL-51, 42 pp., 9 figs., Apr. 1953.

An exposition of the determination of aerodynamic stability derivatives from flight tests on full-scale airplanes presents primarily the philosophy and techniques of Cornell Aeronautical Laboratory. An evaluation of transient response methods, introduced by step displacements of a control surface, and a frequency-response method, produced by sinusoidal oscillations of the control surface at varying frequencies, is presented from both the data-acquisition and the data-analysis standpoints. Determination of the transfer function associated with the airplane by either process is possible, but separation of the individual stability derivatives can be accomplished only in certain instances. Effects of nonstationary flow and aeroelasticity are considered. Examples of results and a bibliography are included to complete a clear statement regarding this important technique.

E. T. Welmers, USA

191. **Amer, K. B., and Gessow, A., Charts for estimating tail-rotor contribution to helicopter directional stability and control in low-speed flight,** *NACA TN* 3156, 54 pp., May 1954.

Theoretically derived charts and equations are presented by which tail-rotor design studies of directional trim and control response at low forward speed (i.e., at tip-speed ratios less than 0.10) can be conveniently made. The use of the charts and equations for tail-rotor design studies is illustrated. Comparisons between theoretical and experimental results are presented.

The charts indicate, and flight tests confirm, that the region of vortex roughness which is familiar for the main rotor is also encountered by the tail rotor, and that prolonged operation at the corresponding flight conditions would be difficult.

The authors are to be commended for presenting a clear and direct analysis of the problem. Reviewer feels, however, that while the assumption of a uniform induced flow is appropriate and facilitates such analyses, under certain conditions it is of questionable accuracy in predicting collective pitch angles and should be so stated.

L. Goland, USA

192. **Coleman, T. L., and Copp, M. R., Maneuver accelerations experienced by five types of commercial transport airplanes during routine operations,** *NACA TN* 3086, 26 pp., Apr. 1954.

193. **Machin, K. E., The performance testing of the Slingsby Sky,** *J. roy. aero. Soc.* **58,** 523, 470–474, July 1954.

194. **Lush, K. J., A survey of performance reduction, with particular reference to turbo-propeller aircraft,** *Aero. Res. Counc. Lond. Rep. Mem.* 2757, 7 pp., Jan. 1950, published 1954.

Author surveys the experimental and analytical methods of aircraft performance reduction. Application is made to the familiar case of a simple jet aircraft where steady level speed is a unique function of engine rpm, aircraft weight, and the air temperature and pressure. By dimensional analysis this function reduces to one in three variables, where two are controllable, greatly simplifying the experimental determination of airplane performance.

The difficulties involved in extending the techniques used in the above case are discussed, especially as they apply to a turbo-propeller aircraft where the steady level speed is also a function of the tailpipe temperature. The effect of interconnection of controls is considered. R. Oldenburger, USA

195. Evans, G. J., Smith, A. G., Shaw, R. A., and Morris, W., Water performance of a four-engined flying boat with step fairings of length 3, 6 and 9 times the step depth, *Aero. Res. Counc. Lond. Rep. Mem.* 2868, 28 pp., Apr. 1941, published 1953.

196. Weaver, A. K., Some additional notes on the derivation of airworthiness performance climb standards, *Aero. Res. Counc. Lond. Rep. Mem.* 2769, 12 pp., Feb. 1950, published 1953.

197. O'Hara, F., A method of performance reduction for helicopters, *Aero. Res. Counc. Lond. Rep. Mem.* 2770, 12 pp., Oct. 1947, published 1952.

The equations for helicopter performance are developed in a form suitable for the reduction of flight test data to standard atmospheric conditions. Simplifying assumptions, such as that of constant blade drag coefficient, are made. Charts are presented on the basis of typical values of certain parameters. These charts may be used also for performance estimation. Additional charts are presented for estimating the effect of changes in gross weight.

Reviewer believes method to be convenient when speed rather than accuracy is desired, and when helicopter has characteristics similar to those assumed. G. Isakson, USA

Aeroelasticity (Flutter, Divergence, etc.)

198. Molyneux, W. G., The flutter of swept and unswept wings with fixed-root conditions. Parts I, II, and III, *Aero. Res. Counc. Lond. Rep. Mem.* 2796, 23 pp., Jan. 1950, published 1954.

Paper presents fixed-root flexure-torsion wind-tunnel studies of flutter on wings with systematically altered taper, inertia axis location, and sweepback. Results are compared in one case with the wing torsion stiffness criterion.

Author concludes flutter speed decreases slightly with small sweepback and then increases rapidly as sweep angle is increased. Forward movement of inertia axis at any given angle of sweep results in increased flutter speed. Correlation and combined results are presented.

Reviewer believes these fundamental studies and extensions proposed by the author will provide corroboration of simple flutter criteria now in use. J. B. Duke, USA

199. Nelson, H. C., and Berman, J. H., Calculations on the forces and moments for an oscillating wing-aileron combination in two-dimensional potential flow at sonic speed, *NACA Rep.* 1128, 16 pp., 1953.

Supersedes article reviewed in AMR **5**, Rev. 1819.

200. Howarth, R. M., and Jones, C. H., Ground resonance of the helicopter, *J. Helicop. Assn.* **7**, 4, 168–189, Apr. 1954.

Self-excited vibrations of helicopters on the ground have been the cause of several accidents. It is therefore essential that the means of insuring freedom from such phenomena should receive serious attention. The theory of R. P. Coleman is briefly reviewed and compared with results obtained from model rotor tests. This comparison affords general confirmation of the theoretical results. The theory of a rotor on idealized supports is applied to a single rotor helicopter of known hub impedance. Then, experimental methods for determining this impedance are described.

Finally, the influence of ground resonance on undercarriage design is reviewed. The influence of shock absorber struts and tires on the coupled rigid body modes of the helicopter is discussed and three undercarriage schemes representing alternative approaches to ground-resonance elimination are examined. It is found that, with respect to ground resonance, the most advantageous system for land-based operations is one in which all the helicopter-undercarriage modes have very low frequencies. An appendix indicates the application of the theory to a twin-rotor helicopter of any configuration. From authors' summary

201. Thurston, A. P., Fifty years theoretical and experimental research in aeronautics, "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris*, 363–381, 1954.

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 25, 34, 220, 253, 272, 273, 274, 286, 289)

202. Priestley, E., A general treatment of static longitudinal stability with propellers, with application to single-engined aircraft, *Aero. Res. Counc. Lond. Rep. Mem.* 2732, 20 pp., May 1944, published 1953.

A general method of treatment of stick-fixed static longitudinal stability with propellers is given, distortion and compressibility effects being neglected. Model full-throttle data on some single-engined fighters are analyzed for the flaps-up condition to establish a basis of estimation of effect of propeller on stability for this type of design.

From author's summary by J. E. Stevens, USA

203. Rogers, G. F. C., Factors influencing the optimum aerodynamic design of cooled turbines, *Aero. Res. Counc. Lond. curr. Pap.* no. 155, 18 pp., 9 figs., July 1952, published in 1954.

An attempt is made to find a criterion for optimum aerodynamic design of cooled turbines. Three types of industrial turbines are investigated: (1) Impulse; (2) 50% reaction with the blade inlet angle equal to one half the outlet angle; and (3) 50% reaction with the blade inlet angle equal to zero; all having the same mass flow and approximately the same disk and blade stresses.

It is found that, although the high flow coefficients (V_a/U_m) are associated with low heat-extraction rates (i.e., low aerodynamic efficiency), the use of high flow coefficients may result in some cases in a slight gain of thermal efficiency. No generalization is offered about the relative effect of the heat-extraction rate and the aerodynamic efficiency on the over-all performance of the gas turbine plant. K. Pilarczyk, USA

204. Schwaar, P., Addition to the theory of supersonic axial compressors (in French), *ZAMP* **5**, 2, 136–150, 1954.

The problem of axial flow with a normal shock in the stator after a rotor with work input varying along the radius is treated.

The following assumptions are made: (1) The flow is axisymmetrical. (2) No radial acceleration exists in the stator, i.e., the flow before and after the shock follows cylindrical surfaces. (3) The angle α of the absolute velocity with the tangential direction follows the law $\tan \alpha = (\tan \alpha_i)(r/r_i)$ where r_i is the hub radius.

The equations of radial equilibrium and the equations relating the states before and after shock (Hugoniot) lead, with the above assumptions, to a unique solution for the Mach number (and thus the energy) before and after the shock as a function of the radius ratio. The Mach number M_i and the angle α_i at r_i appear as

parameters in this equation. The equation shows that the Mach number before the shock decreases monotonically with increasing radius but stays always above 1, even when the radius ratio becomes very large, in opposition to a constant energy flow (free vortex). The energy increases with increasing radius. In a typical example with a hub-to-tip radius ratio of 0.5 and $\alpha_1 = 30°$ at the hub, the work input must be 2.5 times larger at the tip than at the hub, while the absolute Mach number varies from 1.36 at the hub to 1.11 at the tip. If this is not so, then assumptions one to three cannot be fulfilled.

In order to decrease this work input ratio, it is proposed to (a) decrease the radius ratio and (b) increase α_i.

The interrelation between the strong normal shock and the boundary layer is not mentioned.

In the reviewer's opinion it would be worth while to extend this paper to cases where the flow angle α follows other laws than the one expressed by assumption (3), and to find, for instance, a law which minimizes the variation of the work input. It also would be of considerable interest to drop assumption (2) (necessary for the establishment of a normal shock), because an oblique shock might be more favorable in view of the interaction of shock and boundary layer. H. P. Eichenberger, USA

205. de Kovéts, A., and Desmur, G., Pumps, fans, compressors. Centrifugal and axial [Pompes, ventilateurs, compresseurs. Centrifuges et axiaux], Paris, Dunod, 1953, viii + 336 pp.

Design, construction, and performance of centrifugal and axial pumps, fans, and compressors are the subject matter of book. A fundamental knowledge of fluid dynamics and thermodynamics is needed by the reader. First part of the book relates to fundamentals. First chapter is devoted to the general principles of these machines, which, at least from a theoretical point of view, are similar for all. Authors point out differences of behavior of liquids and gases, mainly due to compressibility, viscosity, etc. Reversibility of turbomachines is further discussed. Chap. 2 refers to liquid flow, with a review of main conclusions from Bernoulli's theorem concerning energy transformations. Reviewer finds little opportunity for the term "shock" pressure; it would be better to use stagnation or dynamic pressure, or a similar expression, more in accordance with the real energetic transformation. Chapter continues with a résumé on vortex motion, which is called circulation. While this term generally refers only to the curvilinear integral of velocity around a closed line, authors ascribe circulation to the integral as well as to motion itself. Chap. 3 concerns flow through blades, airfoils, and grids. Fundamental principles of lift and drag are reported.

Several Göttingen and NACA airfoils are represented with their drag and lift diagrams. Several remarks on cavitation are further pointed out. Chapter closes with the study of rows of blades. A useful diagram on the influence of pitch upon drag and lift is presented. Chap. 4 is concerned with energy losses.

Second part relates to design and construction of runners and draft tubes. Chap. 5 is devoted to pump behavior. There, authors define volumetric, hydraulic, and mechanic efficiencies, and velocity triangles. Euler's fundamental formula is derived from customary consideration of velocities transformations. Reviewer thinks that this formula is better derived when it is applied to momentum equation. Specific velocity is defined and related to efficiency for each type of machine. Chap. 6 concerns energy losses and their classification. This subject is clearly developed and includes cavitation effects and pitting. Performance of pump as reversed turbine is subject of chap. 7. Chap. 8 concerns choice of each type of machine. Chap. 9 is devoted to runner design. Valuable graphs are given as means for easy pump and fan design. Chap. 10 considers detail runner design, while chap. 11 is devoted to draft tubes. Chap. 12 takes up axial thrust.

Part 3 is related to mechanical study of pumps and fans. A good many valuable construction details are given. Part 4 concerns special kinds of pumps. Part 5 is devoted to several very interesting examples of pump and fan design. Part 6 treats the behavior of pumps and fans and their tests.

Part 7 is devoted to compressors. It begins with a review of thermodynamical principles concerning compressor performance. Chap. 32 considers energy losses. Chap. 33 treats the compressor choice. Book goes on with design of runners and draft tubes and several remarks on mechanical features of compressors. Book ends with a practical example of compressor design.

Reviewer finds some lack of unity. Cavitation is treated twice with different intensity on p. 22 and on p. 67; choice of types of pumps and fans is treated in chap. 8 and again in chap. 26. Nevertheless, book is a valuable contribution to mechanical-engineering literature. Reviewer thinks it would be useful for design and control of pump plants. Compressor subject is less developed than the other two, so it could be suggested that in a new edition authors might enlarge this part of book in order that the three types of machines be equally treated.

A. Balloffet, Argentina

206. Baron, S., Detect recirculating BF pump load-drop cavitation mathematically, *Power Engng.* **58,** 7, 75–77, July 1954.

Sudden load drop occasionally leads to a set of conditions causing pump cavitation. Article shows how to predict cavitation conditions in recirculating-type boiler feedwater pumps.

From author's summary

207. Millar, D. A. J., Calculation of the catch of water by a jet engine during high-speed flight in cloud, *Nat. aero. Establ. Canad.* LR–78, 32 pp., June 1953.

When the flight speed of a turbojet engine exceeds the air velocity at the engine intake, the oncoming air must both decelerate and diverge as it approaches the engine. If, as in clouds, this air contains droplets of water, these, because of their inertia, will not follow the air streamlines but will follow paths generally less divergent, under the opposing influences of inertia and drag. As a result, the concentration of water in the engine air will be higher as it enters the engine than it was in the undisturbed state. The purpose of this report was to calculate the percentage increase in average concentration caused by the inertia effect for a typical engine configuration, engine speed, and meteorological conditions.

Engine air-flow patterns were plotted for cruise and climb at sea-level conditions, using an electrical analogy tank. The droplet trajectories were calculated, using step-by-step integration of the equations of motion of the droplets.

It was found that 47% extra water would be taken in by the engine during cruise, and 22% extra during climb, in cloud consisting of 20-micron droplets. From author's summary

208. Chirkov, A. A., et al., Locomotives, 2nd ed. (in Russian), Moscow, State Transport Railway, 1953, 695 pp., 572 illus. 22 rub.,, 50 kop. ($2).

This is a text for students of mechanical faculties of Russian transport institutes. The first part (64 pp.) covers Russian locomotive history and gives details of engines built from 1901 to 1953, followed by general performance considerations. The second most important and thorough part (303 pp.) deals with the boiler design and size determinations as evolved by Siromiatnikov and, more recently, Belokon. This part is a most up-to-date and

thorough exposition of Russian locomotive boiler practice, illustrated by numerous test results and detailed boiler calculations. The treatment of the front end (blast pipe, etc.) is somewhat sketchy. The third part (180 pp.) considers the engine proper (stresses in running gear), thermal and mechanical efficiency, balancing and valve gear. The fourth part (80 pp.) is devoted to frame design, a rather oversimplified treatment of running through curves, and problems of derailment, bogie design, stresses in rails, and suspensions. The design of tenders, with particular reference to condenser tenders and their auxiliary equipment, is dealt with in the next part (62 pp.), while future possibilities of improving thermal and mechanical performance are considered in the final part (23 pp.). The numerous component design examples are illustrative of Russian practice only and refer to class F.D., I.S., S.O., L (built between 1931 and 1946), the 1–3 + 3–1 (1949) and 1–5–1 type O R (1952) locomotives. The book is well written and illustrated and gives a good up-to-date account of Russian practice which should be of interest to all concerned with design and performance of locomotives in general and their boilers in particular. J. L. Koffman, England

Flow and Flight Test Techniques

(See also Revs. 161, 168, 178, 190, 269)

209. Kalmus, H. P., Electronic flowmeter system, *Rev. sci. Instrum.* **25,** 3, 201–206, Mar. 1954.

A flowmeter system is described which gives continuous readings of flow velocity, with a fast rate of response. The "upstream-downstream" method is used in which velocity of a fluid is determined by measuring the phase difference between an upstream and downstream ultrasonic wave of, say, 100,000 cycles. The functions of the transmitting and receiving transducers are interchanged at a fast rate, say 100 cps, allowing the use of a synchronous rectifier. In this way, no long-time stability of the phasemeter is required so that very small flow rates can be measured. Velocities as low as 0.1 cm/sec were successfully measured. A special commutator switch with very low transfer capacitance and, as an alternative, an electronic switch are described. The transducers used are barium titanate crystals mounted in a manner so that their contact with the fluid is avoided. From author's summary

210. Todd, K. W., Apparatus for the remote recording of flow conditions, *Aero. Quart.* **4,** part 4, 400–416, Feb. 1954.

An instrument is described which detects total pressure, total temperature, and direction of flow simultaneously in a stream tube of $^1/_{16}$-in. diam. The observed directions and pressures are transmitted electrically to a remote station where they appear as pencil traces on a paper record which moves at a rate proportional to the traverse rate of the instrument. The temperature is noted at intervals and added manually to the trace. Integrators are included which permit rapid assessment of mean pressure and direction at the conclusion of a traverse, the control and maintenance of setting of the instrument being semi-automatic. A further development is also noted whereby total pressure and direction in three dimensions can be observed either manually or remotely by automatic means.

From author's summary

211. Johnson, T. W., and Meachen, D., Blast furnace exploration. Use of a continuous flow counter, *Research, Lond.* **7,** 9, 356–359, Sept. 1954.

The use of a continuous flow counter in the measurement of the transit time of the gases through a furnace burden is described. A method of introducing a succession of pulses within a short period of time, coupled with the use of a high-speed recorder to give a continuous record of the count rate in the chamber, enables a number of results to be obtained rapidly. The method may have wider application in other industrial problems.

From authors' summary

212. MacMillan, F. A., Viscous effects on pitot tubes at low speeds, *J. roy. aero. Soc.* **58,** 524, 570–572, Aug. 1954.

Measurements were made of the pressure in a blunt-nosed pitot tube, in an air stream at Reynolds numbers from about 15 to 1000. The results are expressed in terms of a pressure coefficient $C_p = (P - p)/(^1/_2 \rho V^2)$, where P is the pressure in the pitot tube, ρ the density of the fluid, and p and V are the static pressure and velocity in the undisturbed stream. As found in previous investigations, C_p becomes greater than 1 at low Reynolds numbers, the increase being about $1^1/_2\%$ at a Reynolds number of 50 (based on external tube radius). In disagreement with the work of Hurd, Chesky, and Shapiro, no decrease of C_p below 1 was found at any Reynolds number.

When the values of C_p found by various experiments are plotted against Reynolds numbers based on internal tube radius, it is found that the curves are in closer agreement than when the external radius is used. From author's summary

213. Delatycki, O., and Kettleborough, C. F., Traversing mechanism for pyrometer and pitot tube, *Engineering* **177,** 4607, 624–625, May 1954.

214. Mielenz, K.-D., Pressure measurements with the Pirani gage (in German), *Z. angew. Phys.* **6,** 3, 101–104, 1954.

The Pirani gage is used for measuring pressures under high vacuum conditions where the thermal conductivity of gases varies with the pressure. It depends on measurement of the heat losses from a heated filament to the gas surrounding it. The author analyzes the effect of vessel temperature, filament temperatures, and the electrical characteristics of the Wheatstone bridge in which the gage is connected to establish conditions of measurement as to sensitivity and precision. The analytical results are used as a guide in varying the perimeter of a particular gage whose construction is shown. By keeping the outer wall of the gage at liquid air temperature and by using low filament temperature, the sensitivity of the gage was improved by a factor of about 7.5. Under optimum conditions, this gage could be used to measure pressures down to approximately 10^{-8} mm of mercury. M. A. Mayers, USA

215. Sugiura, Y., Experimental studies on the force exerted on a disc placed in a flow of rarefied gas, *J. phys. Soc. Japan* 9, 2, 244–248, Mar.-Apr. 1954.

Uyeda has devised a flow-meter in vacuum technique [AMR **7,** Rev. 2583] whose principle is simply to measure the force on a disk placed in a pipe through which a rarefied gas flows. As a basic study of the meter, the force was measured under various conditions, namely, the pressure of the flowing gas, the diameter of the disk, and the position of the disk along the radius of the pipe being varied. The results of the measurement are shown in figures and expressed by empirical formulas.

The results here obtained are in agreement with theoretical expectations for Knudsen and Poiseuille flow. In the Knudsen flow, it is confirmed that the assumption of diffuse reflection of molecules on the disk is adequate. In the intermediate flow case between Knudsen and Poiseuille flow, the force shows an anomalous behavior which seems to have some correlation with the phenomena observed by Knudsen. From author's summary

216. **Kennedy, V. C., Determining weight electronically. A tool for control and measurement procedures,** *Mech. Engng., N. Y.* **76,** 2, 159–165, Feb. 1954.

217. **Collett, C. T., Simplification of calculations in routine density and volumetric determinations,** *J. Res. nat. Bur. Stands.* 52, 4, 201–204, Apr. 1954.

In density and volumetric determinations, certain methods of weighing have encouraged the use of approximations. These can be avoided by minor changes in procedure that simplify calculations. The use of counterpoises is shown to eliminate some buoyancy corrections. From author's summary

218. **Chaleat, R., The accuracy of conical pendulums for time measurement** (in French), *C. R. Acad. Sci. Paris* **238,** 15, 1570–1573, Apr. 1954.

219. **Stokes, G. M., Davis, D. D., Jr., and Sellers, T. B., An experimental study of porosity characteristics of perforated materials in normal and parallel flow,** *NACA TN* 3085, 24 pp., Apr. 1954.

An experimental investigation was conducted in order to determine the porosity characteristics of perforated materials in normal and parallel flow. The results of the normal-flow test showed that the porosity of the material is governed principally by its open ratio, but that the density has a slight effect. When the same material was tested under parallel-flow conditions, the effective porosity dropped markedly as the stream velocity increased.

A new definition is given which permits the concept of a discharge coefficient to be extended to the case of parallel flow. An essential feature of this extension is that the discharge coefficient is based on the total velocity in the discharge jet rather than on some velocity component normal to the wall. Discharge coefficients were determined for the test materials for parallel-flow stream velocities ranging from 200 to 1400 fps. The most important parameter in determining the discharge coefficient of the material was found to be the ratio of the stream velocity to the jet velocity. For the same velocity ratios, the discharge coefficients at the supersonic velocity tested were less than those for the subsonic velocities tested.

From authors' summary by A. Miele, USA

220. **Bruin, F., Theory and application of high resolution interferometers. I. The etalon of Fabry and Perot. II. Measurements in the optical and microwave region. III. Limitations to resolution,** *Proc. k. Ned. Akad. Wet.* (*B*) **56, 57,** 5, 1; 515–537, 125–137, Nov./Dec. 1953, Jan./Feb. 1954.

221. **Canac, F., Propagation, interference, reflection, absorption, diffusion of sonic and ultrasonic waves visualized by the strioscopic method** (in French), *Acustica* **4,** 2, 320–328, 1954.

Author reviews experimental production and optical origin of visible sonic waves. The means of visualization are adapted to the wave structure of interest. A selection of instructive photographs shows many details of all the propagation phenomena. The method is applied to two-dimensional room acoustics where the original ratio of wave length to the room dimensions must accord to the model. Another application shows an acoustic analog to the electromagnetic wave guide.

P.-P. Heusinger, Germany

222. **Klein, H., and Sedney, R., Some basic concepts for analyzing dynamic flight-test data,** *J. aero. Sci.* **20,** 11, 740–748, Nov. 1953.

See AMR **7,** Rev. 1576.

Thermodynamics

(See also Revs. 100, 109, 143, 156, 240, 262)

223. **Winter, F. W., Technical thermodynamics [Technische Wärmelehre],** Essen, Verlag W. Girardet, 1954, 312 pp., 240 figs. DM 19.80.

This book is primarily designed as a text for technical institutes and for self study. Extent and material covered match simpler American undergraduate texts. Chapters, are: Fundamentals; Thermal effects in solids; Thermal effects in liquids; Ideal gases; Prime movers; Real gases; Gas mixtures; Vapors; Refrigeration; Heat pumps; Combustion; Modern flow machinery. Text is aided by numerous good schematics.

Presentation differs widely from American textbook practice; e.g., a general statement of the first and second laws is introduced as part of the chapter on ideal gases, and flow processes are completely neglected except in the last chapter, which first mentions the continuity equation. Clear statements of fundamentals are sacrificed throughout to a large number of working formulas and tabulations. F. Landis, USA

224. **Green, R. B., A new examination of the laws of thermodynamics,** *Amer. J. Phys.* **22,** 4, 191–193, Apr. 1954.

The first law is stated in a new simpler form which is qualitative, and its quantitative content is proved as a corollary. This is done for both the Poincaré and the Carathéodory methods. A statement of the second law is given. Minimum requirements for statements of the laws are discussed and new alternative statements suggested. From author's summary

225. **Bordoni, P. G., Adiabatic transformations of finite amplitude** (in Italian), *Ric. sci.* **23,** 9, 1569–1578, Sept. 1953.

Author uses a thermodynamic potential, derived in a previous but as yet unpublished paper, to evaluate temperature changes in such transformations. D. R. Bland, England

226. **Rocard, Y., The fluctuations in density and the supersaturation of vapors** (in French), *C. R. Acad. Sci. Paris* **238,** 13, 1391–1392, Mar. 1954.

227. **Dzung, L. S., The medium in fluid mechanics,** *J. aero. Sci.* **20,** 9, 650–651, Sept. 1953.

This paper describes an equation of state as $Z \equiv pv/RT = Z(s)$ which has all the mathematical properties of an ideal gas. It can be used in the mathematical development in fluid mechanics to predict more accurately the behavior of fluids in regions where they exhibit nonideal behavior. Having the same mathematical properties as the equation of state $pv/RT = \text{const}$, it provides the same simplification with improved results. J. A. Clark, USA

228. **Wolf, H. C., A simple method for the determination of the ratio c_p/c_v** (in German), *Z. Physik* **137,** 5, 572–574, 1954.

The ratio c_p/c_v (for perfect gases) is determined by measuring the natural frequency of oscillation of mercury in a U-tube manometer with and without equal samples of gas confined above the two legs of the manometer. The method is recommended for classroom demonstration. S. Gratch, USA

229. **Watson, G. M., Stevens, A. B., Evans, R. B., III, and Hodges, D., Jr., Compressibility factors of nitrogen-propane mixtures in the gas phase,** *Indust. Engng. Chem.* **46,** 2, 362–364, Feb. 1954.

Nitrogen and propane are important and common components

of industrial gaseous systems. The literature contains no tabulation of compressibility factors of nitrogen-propane mixtures in the gas phase.

The isotherms reported are at 259.08 and 300.00 F. For these isotherms, the approximate pressure ranges covered extend from 100 to 3500 psia for the first and from 100 to 6000 psia for the second. From authors' summary

230. Steggerda, J. J., Additivity of the thermodynamic potential in homologous series of hydrocarbons (in Dutch), *Ingenieur* **66,** 4, Ch. 8–Ch. 11, Jan. 1954.

231. Lee, J. F., Thermodynamic properties of liquid sodium, *Nucleonics* **12,** 4, 74–77, Apr. 1954.

A convenient tabulation of specific heat, enthalpy, entropy, density, and coefficient of cubical expansion is presented in engineering units over the temperature range 208 to 1500 F. Advantages of tabulating the quantities in one source and in engineering units are obvious. The reviewer believes, however, that tabulation in 5-deg intervals is not warranted and, indeed, is much less convenient than tabulation in intervals of 10 deg. The latter interval would have given a table suitable for linear interpolation. In fact, over most of the range, 100-deg intervals would have been equally suitable. The author does not make clear whether the equations given are his own correlations or simply reductions to engineering units of equations given by the original experimenters. J. Hilsenrath, USA

232. Daunt, J. G., and Smith, R. S., The problem of liquid helium—some recent aspects, *Rev. mod. Phys.* **26,** 2, 172–236, Apr. 1954.

233. Accascina, F., and De Rossi, M., Thermodynamic properties of the PbO_2-Zn storage battery in acid electrolyte, *Ric. sci.* **24,** 1, 42–48, Jan. 1954.

234. Nakaya, U., and Matsumoto, A., Simple experiment showing the existence of "liquid water" film on the ice surface, *J. Colloid Sci.* **9,** 1, 41–49, Feb. 1954.

Two small ice spheres are suspended by thin cotton filaments. The top of one filament is displaced horizontally by a screw motion. The movable ice sphere is brought in contact with the stationary sphere, and then the screw is turned back. The normal cohesion is measured by the inclination of the filament when the spheres are separated. Sometimes the ice spheres showed a rotation before separation. The rotation took place more frequently in the range of temperatures near the freezing point, but it was observed once at −70 C, the lowest temperature when distilled water was used. When ice spheres made of 0.1% solution of NaCl were used, this rotation was very likely to occur and was observed quite often at −14 C. Successive rotations were sometimes observed in this case. These phenomena are explained by considering a model of the point of contact, which is composed of a solid ice bond and the surface films of a liquid-like nature. The relation between the strength of the ice bond and the area of contact is calculated by using Hertz's equation.

From authors' summary

235. Neel, C. B., A procedure for the design of air-heated ice-prevention systems, *NACA TN* 3130, 63 pp., June 1954.

A procedure proposed for use in the design of air-heated systems for the continuous prevention of ice formation on airplane components is set forth. Required heat-transfer and air-pressure-loss equations are presented, and methods of selecting appropriate meteorological conditions for flight over specified geographical areas and for the calculation of water drop-impingement characteristics are suggested.

In order to facilitate the design, a simple electrical analog was devised which solves the complex heat-transfer relationships existing in the thermal-system analysis. The analog is described and an illustration of its application to design is given.

From author's summary by M. Tribus, USA

236. Stephenson, J. L., Theory for the design of apparatus for drying frozen tissues, *Bull. math. Biophys.* **16,** 1, 23–43, Mar. 1954.

237. Jennings, E. G., and Monteith, J. L., A sensitive recording dew-balance, *Quart. J. roy. meteor. Soc.* **80,** 344, 222–226, Apr. 1954.

The instrument described gives a continuous record on photographic paper of the change in weight of a naturally exposed grass surface, 330 cm^2 in area. The sensitivity is 2 mg cm^{-2} per cm of record and the time scale is 0.5 hr/cm. Observations suggest that on very calm nights the condensation of vapor reaching the surface by diffusion from the atmosphere is only a small fraction of the total "dew." The maximum rate of deposition that has been observed on short grass is 0.03 mm hr^{-1}.

From authors' summary

238. Machlin, E. S., Role of strain energy in solid solution thermodynamics (Technical Note), *J. Metals* **6,** 5, sect. 2, 592–593, May 1954.

239. Druyvesteyn, M. J., and Blok van Laer, K. J., Thermoelectric power of cold-worked copper at low temperature, *Nature* **173,** 4404, p. 591, Mar. 1954.

Heat and Mass Transfer

(See also Revs. 73, 203, 206, 223, 231, 232, 235, 236, 268, 274, 299, 300, 303, 306, 307, 308, 311)

240. McAdams, W. H., Heat transmission, 3rd ed., New York, McGraw-Hill Book Co., Inc., 1954, xiv + 532 pp. $8.50.

The long-awaited third edition of McAdams' widely used text and reference work probably brings the subject as nearly up to date as is presently practicable. In a science that is moving forward as rapidly as heat transmission is today, it is hardly possible to produce a definitive work, and McAdams has done a remarkable job even though some sections were already dated on the date of publication.

All of the chapters appear to have been completely rewritten with new material introduced on virtually every page. Two entirely new chapters on compact heat exchangers, packed and fluidized systems, and high velocity flow, rarefied gases, reflect new areas of interest.

The chapter on conduction has been expanded into two chapters on steady-state and transient conduction, but the treatment is still very brief and of limited usefulness. Numerical methods for both steady-state and transient conduction are discussed.

Hottel's chapter on radiant-heat transmission is a considerable improvement over the similar chapter in the earlier edition. The derivation of the gray enclosure factor is explained in detail, and the section on gaseous radiation has been greatly expanded.

The chapter on dimensional analysis is now a short but excellent introduction to the subject, and is especially recommended to the reader confused by various dimensioning systems in use today.

In his chapter on flow of fluids, McAdams has now cleared up the confusion between the energy balance and the force balance, and the result should be accepted by the thermodynamicist. The original treatment certainly was not.

The chapters on convection, as before, comprise a substantial portion of the book, and again it is here that McAdams makes his greatest contribution. There is nowhere in the literature so thorough a condensation and evaluation of experimental data. The entire treatment has been reorganized with natural convection occupying a chapter of its own. Forced convection inside tubes is handled very nicely by starting with a discussion of the heat- and momentum-transfer analogy methods, which helps the reader gain a physical feel for the convection phenomena and, above all, brings out the significance of the Prandtl number. Most of the significant experimental data obtained up to within the past three years are included. Possibly because of the great amount of data now available, McAdams in many cases appears to be more content than previously to merely quote experimental results and leave evaluation up to the reader. The new chapters on compact heat exchangers and high velocity flow are adequate summaries of the subjects, but the reader with more than casual interest is advised to refer to McAdams' source material.

Perhaps in no phase of heat transmission has as much fundamental progress been made in the last decade as in boiling. The boiling chapter is almost completely new, reflecting this progress, but unfortunately the job is only half finished and this chapter is already far behind.

McAdams' appendix remains one of the best sources of thermal properties data. W. M. Kays, USA

241. Seiffert, K., Insulation engineering [Der Wärmeschutz-Ingenieur], München, Carl Hanser Verlag, 1954, 334 pp., 107 figs., 57 tables. DM 18.50.

This book, containing many tables, curves, and examples, may very well serve as a handbook in its field. Part I deals with basic relationships in heat transfer and discusses problems of heat loss, temperature drop, prevention of sweating, and low-temperature insulation. Part 2 covers the physical and chemical characteristics of insulating materials. Part 3 includes calculations of the most economical thickness of insulating material for both high- and low-temperature insulation. Part 4 deals with various mounting techniques. T. Y. Toong, USA

242. Kim, E. I., Diffusion of heat in an infinite, heterogeneous body, in two dimensions (in Russian), *Prikl. Mat. Mekh.* **17**, 3, 555–568, Sept./Oct. 1953.

Using a Green's function approach, author presents a rigorous mathematical treatment of the classical problem of diffusion in two infinite plates of different conductivities, joined along a line at $x = x_0$. For an arbitrary initial distribution of temperature in two dimensions and the usual continuity conditions at the line of jointure, a solution appears in the form of two singular integral equations, one for each side of the line $x = x_0$. These are reduced to a single integral equation, solvable by a series involving the characteristic values. When the initial function depends on x only, or is constant, the solution reduces to well-known textbook forms. Wm. M. Stone, USA

243. Stalder, J. R., and Nielsen, H. V., Heat transfer from a hemisphere-cylinder equipped with flow-separation spikes, *NACA TN* 3287, 29 pp., Sept. 1954.

The significant practical problem of the pressure drag and heat transfer from a blunt-nosed body in subsonic and supersonic flow is investigated experimentally. The tests confirm a previous result which showed that a reduction in pressure drag may be achieved through the use of spikes attached to a hemispherical-nosed body. It was found, however, that, despite the drag reduction, the average heat-transfer rate is approximately doubled regardless of the spike configuration. Tests conducted with the spikes removed indicated that if flow conditions are evaluated behind the normal shock wave, it is possible to predict the heat-transfer characteristics of the hemisphere by using subsonic relationships. J. Persh, USA

244. Romanenko, S. V., The flow of a viscous gas through a cylindrical tube with (convective) heat exchange (in Russian), *Dokladí Akad. Nauk SSSR (N.S.)* **91**, 6, 1289–1292, Aug. 1953. (English translation by M. D. Friedman is on file with scientific Translations Division, Library of Congress.)

Paper deals with the problem of high-speed flow of a compressible fluid through a tube of uniform cross section on the basis of the accepted one-dimensional engineering approximation and for a Prandtl number $Pr = 1$, assuming an empirical condition related to Reynolds' analogy of the form

$$dQ_a/dL_r = [-gc_p(T_0 - T_{st})]/w^2$$

(dQ_a is heat added; dL_r work due to friction; T_0 stagnation temperature, T_{st} static temperature, the remaining symbols being standard.) The exchange of heat is accounted for by the introduction of the parameter $\sigma = T_0/T_{st}$, no attempt being made to specify any actual conditions for the transfer of heat across the tube to the gas. Viscosity is accounted for by a frictional coefficient ξ assumed constant along the tube.

Author describes a general method of graphical integration and gives explicit formulas for both very large and very small values of Mach number M. Integration is performed in the λ, σ-plane (meaning of λ and several other symbols is not explained, but presumably is contained in references quoted) and a method of computing the variation along the tube is given, a new length parameter, $\chi = \xi x/2D$ being used. The paper gives only final results and is highly compressed. J. Kestin, USA

245. Mickley, H. S., Ross, R. C., Squyers, A. L., and Stewart, W. E., Heat, mass, and momentum transfer for flow over a flat plate with blowing or suction, *NACA TN* 3208, 149 pp., July 1954.

The effect on the boundary layer of sucking or blowing air through a porous flat plate into or out of an air stream flowing parallel to the plate was studied theoretically and experimentally.

The laminar boundary-layer equations describing the transfer of momentum, mass, and heat are discussed; solutions are obtained with the assumption of negligible aerodynamic heating and constant properties for flow over a flat plate for a range of Prandtl and Schmidt numbers. Qualitative information for more general flow conditions (including turbulent flow) is obtained by investigation of a greatly simplified physical model which this paper calls "film theory." Diagrams are presented from which the effect of the blowing or sucking rate on the transfer parameters for momentum, heat, and mass can be obtained.

The experimental investigation comprises measurements of velocity and temperature profiles throughout the boundary layer and of friction and heat-transfer coefficients. The investigation is made on a flat porous plate which constitutes one side of a rectangular tunnel. Air is blown through the tunnel and along the porous plate with a locally constant velocity. Suction is provided ahead of the porous plate to approximate conditions where the boundary layer starts at the leading edge. The main stream velocity was varied between 5–60 fps which resulted in a Reynolds number range from 6500–3,300,000. The velocity of the

air passing the porous plate ranged from −0.3 to 0.26 fps. Constant velocity over the plate surface as well as a distribution proportional $1/x^{1/2}$ and $1/x^{0.2}$ could be adjusted (x distance from leading edge).

To the reviewer's knowledge, this paper presents, for the first time, extensive information on flow conditions over a plate with suction or blowing. It has already been utilized, since its publication, for improved theories in the turbulent-flow range.

E. R. G. Eckert, USA

246. Mims, L. S., and Kleber, J. A., A test loop for determining heat-transfer coefficients by the thermal-cyclic method, ASME, Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-48, 11 pp.

Work was done to prove reliability of design and instrumentation of test loop. Thermal cyclic method has two advantages over steady-state method of measuring convective film coefficients of surfaces with odd physical shape. Heat need not be removed from solid, and solid surface temperatures do not have to be measured. Only temperatures in and out of test passage are required, but change of temperature with time must be determined at speed dependent on cyclic frequency of heat input. Authors chose sine-wave variation as mathematics is simplified. Tests with distilled water at flows from 4 to 15 fps agreed within ±20% of Colburn equation, $Nu = 0.023\ Re^{0.8}Pr^{0.33}$.

Sine-wave heat input was generated by electrical resistance elements fed from the output of two d-c generators connected in series. The field of the generators was varied sinusoidally by means of power supplied through a circuit comprising a multitap transformer provided with a variable-speed motor-driven commutator, followed by a rectifier and suitable slip rings.

Temperatures were measured by resistance thermometers made of Balco, 70% Ni, 30% Fe mounted on plastic, same as heater grids.

D. Aronson, USA

247. Hutchinson, F. W., Heat transfer to or from water by free convection, *Heating and Ventilating* **51,** 9, 80–81, Sept. 1954.

Author presents a graphical representation of the film heat-transfer equation under free convection for water on outside tube surfaces. The recommended equation [see McAdams, "Heat transmission," 2nd ed., eq. 23, p. 244, 1942] was first stated by Lorenz in 1881, in which he related the Nusselt, Grashof, and Prandtl dimensional quantities.

The five physical quantities for water appearing in the free-convection equation must be evaluated for the assumed mean temperature of the fluids inside and outside the pipe. Employing the author's graphical solution, one may determine the film transfer factor for free convection in water directly without calculation and ascertaining the physical constants. This is a very convenient method which gives good accuracy.

H. Majors, Jr., USA

248. Schmeidler, F., Simultaneous diffusion of convection and heat in the atmosphere (in German), *Meteor. Rdsch.* **7,** 1/2, 1–6, Jan./Feb. 1954.

Schmeidler, using relations developed in his studies of diffusion of heat and convection in stars, deduces equality of the *Austausch* (exchange) coefficients for momentum and heat transfer in lowest 100 meters of earth's atmosphere. Employing this concept together with notion of an *Austausch* whose value is a function of the vertical gradient of potential temperature, and allowing for diurnal change of momentum and potential temperature (expressed as Fourier series), author derives five simultaneous second-order differential equations representing the diffusion of these properties. With several simplifying assumptions, the set of equations is solved. End result is, assuming a constant gradient of potential temperature and employing observed diurnal temperature variation data, a computed diurnal variation of *Austausch* (at 45 meters above soil surface) which agrees remarkably well with experimentally measured *Austausch* diurnal variations. Work is largely mathematical. Simplifying assumptions, mathematically necessary, disregard some meteorological facts (e.g., assumed potential temperature gradient independent of height).

R. C. Staley, USA

249. Böckman, O. C., Some experiments with scale models of electrothermic furnaces, *J. Electrochem. Soc.* **101,** 10, 493–496, Oct. 1954.

Reproduction of temperature distribution in furnaces of different size is shown, by dimensional analysis, to require direct proportionality between power input and linear dimensions of the furnace, if transfer of heat by conduction is a controlling factor. Experiments with scale models indicate the importance of correct temperature gradients as a criterion of similarity. A 1:5 linear scale model of an industrial furnace for calcining anthracite has been successfully run according to this criterion. The principle has been extended to electric smelting furnaces with good results.

From author's summary

250. Ghai, M. L., and Pandher, B. S., and Harikishandass, Manufacture of reflector-type direct solar cooker, *J. sci. indust. Res. India* **13,** 5, 212–216, May 1954.

The production of small solar cookers used to a considerable extent in India is discussed. Assembly takes place in an industrial plant. A parabolic reflector of 48-in. diam concentrates radiation from the sun on the bottom of a water heater. The reflector is made from aluminum by spinning. It is anodized to obtain a thin protective coating of alumina. A simple mounting permits adjustment of the mirror and its guiding. Assembly and inspection of the equipment are discussed and flow sheets given.

W. M. Conn, USA

251. Dusinberre, G. M., Calculation of transient temperatures in pipes and heat exchangers by numerical methods, *Trans. ASME* **76,** 3, 421–426, Apr. 1954.

Approximate difference equations are developed for the numerical calculation of transient heat exchange in long conduits. Linear difference equations, along with corresponding convergence criteria, are applied to cases of single- and double-tube counterflow heat exchangers with known mass-flow rates and known initial tube and fluid temperature distributions. Wall and tube temperature histories are calculated for the special case of an externally adiabatic tube with variable fluid entrance temperature and operating under conditions of reversed flow. Numerical temperature histories for another special case of a single-tube exchanger are found to be within 2% of exact values calculated by Rizika [see AMR **7,** Rev. 2606].

P. J. Schneider, USA

252. Hahnemann, H. W., Temperature effectiveness of heat exchangers with regard to heat conduction in longitudinal direction. Part II (in German), *Forsch. Geb. Ing.-Wes.* **19,** 4, 105–114, 1953.

Applications of the approximate theory [part I, see AMR 7, Rev. 1298] to rotating matrix regenerators. Influence of longitudinal heat conduction in the matrix is demonstrated in terms of dimensionless design parameters, including discussion of non-steady flow effects for moderate blow times. Numerical examples and diagrams are presented.

Parts 1 and 2 together are practically identical with Mem. no.

36, National Gas Turbine Establishment, TPA3/TIB, Ministry of Supply, Millbanks, London, SW 1, "Approximate calculation of thermal ratios in heat exchangers including heat conduction in direction of flow" (in English), by the same author.

H. H. Korst, USA

253. **Fulton, S. D., A short method for the evaluation of the effect of some thermal-cycle variations on steam-turbine heat rates,** *Trans. ASME* **76,** 4, 655–663, May 1954.

See AMR **7,** Rev. 1267.

254. **Wetenkamp, H. R., Thermal checking of wrought-steel railway wheel material,** *Trans. ASME* **76,** 4, 649–654, May 1954.

See AMR **7,** Rev. 1800.

Combustion

(See also Revs. 211, 223, 230)

255. **Graf, E. G., Carman, E. P., and Corey, R. C., Pure crossfeed ignition in fuel beds,** *Combustion* **26,** 3, 59–66, Sept. 1954.

The rate of ignition was measured by thermocouples in a vertical bed of fuel ignited at the top with air blown across at various rates from a vertical front grate on one side to a water-cooled grate on the other. It was found that the rate of ignition continued to increase indefinitely as the air mass flow rate was increased up to the highest value that fan power allowed (1200 lb air/hr/ft^2), unlike the underfeed system which showed a maximum rate of ignition. Four fuels (high-temperature coke, high-volatile coal, anthracite, and a sub-bituminous coal) were tested and the rates of ignition (inches per hour) were found to be in that order, with high-temperature coke fastest. This is quite contrary to the order expected from reactivity and ignition temperatures and is explained as being due to the blanketing of radiation to the cold fuel by volatiles and to differences in thermal diffusivity. It is suggested that the high ignition rates obtainable in cross-feed with high air-flow rates could lead to the development of a new type of fuel bed.

M. W. Thring, England

256. **Mullins, B. P., Combustion in vitiated air,** Colloquium, AGARD, Cambridge Univ., Dec. 7–11, 1953, "Selected combustion problems, fundamentals and aeronautical applications," London, Butterworths Scientific Publications, Ltd., 1954, viii + 534 pp., 447–489.

Paper is primarily a survey of the literature of the past fifty years on the subject of combustion in vitiated air. Mr. Mullins has defined vitiated air as air with "an oxygen content which is less than that of ordinary air." This wide definition would not include "air" consisting of, for example, 21% oxygen and 79% argon as the diluent instead of nitrogen. Although the paper is primarily a literature survey, its content is enhanced by the fact that the author has drawn heavily upon experimental work done by himself and his associates.

Practical fields of application of the material presented are mentioned as being primarily in the fields of fire extinction and prevention and in the gas-turbine combustion cycle.

Following a historical introduction, the bulk of the paper consists of a section entitled "Pre-flame processes in vitiated air." Actually, phenomena occurring after the establishment of a flame are discussed as well. Specific items discussed are: Fuel injection, fuel vaporization, interdiffusion of fuel and air, spark ignition, spontaneous ignition, flame appearance, flame temperature, chemical reaction rate, flame propagation rate, inflammability limits, and successive combustion.

Following these discussions on a rather fundamental level, two specific applications are discussed and worked out in some detail by means of charts and nomograms; namely, a particular gas-turbine combustion chamber, and combustion with recirculation. The performance of the gas turbine as indicated by stability, flame length, and combustion efficiency is worked out for the case of vitiation produced by the precombustion of kerosene, $C_{11.6}H_{23.2}$, and the addition of water vapor. The same method of vitiation was used in the recirculation studies. An ingenious four-variable network nomogram is presented for predicting the temperature of the vitiated air fed to a combustion chamber for a particular temperature of the recycled vitiated air and a certain recirculation fraction.

This paper represents a considerable amount of work by Mr. Mullins and is a definite contribution to the literature on fundamental combustion. It will be quite valuable as a reference work for investigators in this field. A bibliography of 105 references is given, which in itself is a useful item.

J. T. Agnew, USA

257. **Botha, J. P., and Spalding, D. B., The laminar flame speed of propane/air mixtures with heat extraction from the flame,** *Proc. roy. Soc. Lond.* (*A*) **225,** 1160, 71–96, Aug. 1954.

Paper describes a new method of flame-velocity determination which appears to be useful over wide ranges of flame velocity. A water-cooled porous plate is inserted at the mouth of a burner. Its function is to give to the issuing combustible mixture a flat velocity distribution while at the same time removing heat imparted to it by the adjacent flat flame front. The rate of heat removal by the water-cooled porous disk is a function of the gas-air-mixture ratio and of its issuing velocity. For a flat flame, this issuing velocity is the flame velocity. Therefore, for a given air-fuel ratio, flame velocity can be plotted as a function of rate of heat removal. Extrapolating this curve to zero heat removal gives a value of adiabatic flame velocity for this air-fuel ratio.

The authors outline a method of determining the predicted flame velocity as a function of gas-mixture temperature from data where room-temperature mixtures were used. An excellent description of the cellular flames which are obtained under certain conditions is included.

Data for adiabatic flame velocities for propane-air mixtures are presented for the entire range of inflammability and show good agreement with results obtained by other workers.

T. W. Price, USA

258. **Rappeneau, J., Speed of flame propagation in a mixture of air and combustible liquid** (in French), *C. R. Acad. Sci. Paris* **238,** 11, 1192–1194, Mar. 1954.

259. **DeZubay, E. A., A study of flame stability based on reaction rate theory,** ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-27, 20 pp.

Experimental studies of burning in the wake of circular disks of various sizes are reported. Two test ducts of different diameters were employed as well as a range of velocities and pressures. Homogeneous air-fuel mixtures were used with propane and hydrogen as fuels. The limiting fuel-air ratios are correlated with velocity, pressure, and disk size. The author makes certain assumptions to justify the correlation on a theoretical basis, considering the combustion zone as a turbulent chemical reactor. Steps necessary for the evaluation of stability limits with a minimum of testing are outlined.

Although the reaction constants and mass-transfer coefficients obtainable are not considered altogether satisfactory by the author, the method of predicting the behavior of flame holders should be useful.

E. C. Wilkerson, USA

260. Springall, H. D., White, T. R., and (in part) Cass, R. C., Heats of combustion of molecular structure. Part I. The resonance energy and structure of cyclo-octatetraene, *Trans. Faraday Soc.* **50,** part 8, 815–819, Aug. 1954.

An experimental combustion calorimetry procedure is described and the method of deriving molecular energetics from combustion calorimetric data is recorded. The evidence for the molecular structure of cyclo-octatetraene is reviewed in the light of the molecular energetics of this substance.

From authors' summary

261. Gray, P., and Lee, J. C., The combustion of gaseous hydrazine, *Trans. Faraday Soc.* **50,** part 7, 719–728, July 1954.

262. Bauer, T. W., and Dorland, R. M., Thermodynamics of the combustion of sodium-base pulping liquors, *Canad. J. Technol.* **32,** 3, 91–101, May 1954.

263. Yagi, S., and Saji, K., Problems of turbulent diffusion and flame jet, Fourth Symp. (International) on Combustion, 771–781, 1953; Baltimore, Md., Williams & Wilkins.

The derivation of general equation for the combustion rate of fuels is presented. This equation provides a method for calculating flame length and approximate distribution of flame temperature of homogeneous and heterogeneous turbulent flames. If flame length is defined as that distance from the nozzle corresponding to 97% combustion, the prediction of the flame-length equation is in good agreement with the flame-length data of other investigators wherein the criterion for flame length is 99% combustion. Visual experiments by the authors on both homogeneous and heterogeneous flames are reported, which check the predictions of their equations. Agreement is good with and without primary air and for a variety of orifices. It is assumed throughout that chemical reaction rate is very large compared with mixing rate. Data are not presented for confirmation of the equation predicting the flame temperature profiles. M. Baker, USA

264. Barr, J., Diffusion flames in the laboratory, *AGARD Memo.* AG11/M7, 10 pp., May 1954.

Paper reviews the literature on diffusion flames and cites some fifty references of original and summarizing work. Turbulent diffusion flames and vibrating diffusion flames are included. Suggestions are made for further research with particular emphasis on the velocity pattern in laminar diffusion flames, flame-anchoring mechanisms, and the methods of excitation of flame vibrations. W. R. Hawthorne, England

265. Manson, N., Formation and speed of explosive spherical waves in gaseous mixtures (in French), *Rev. Inst. fr. Petrole et Ann. Comb. liq.* **9,** 4, 133–143, Apr. 1954.

Author explains experiments carried out on mixtures with oxygen of various gases: acetylene, propane, gas with ethylene and methane base, natural gas from St. Marcet. These gaseous mixtures were contained in transparent latex balloons of 30, 38, and 60-cm diam. By adopting a convenient system of lighting placed in the center of the balloons, it was possible to register spherical explosive waves having the same speed as in tubes and in a large range of mixture strength (although considerably narrower than in tubes), which is function of the method of lighting.

These waves are often set in motion near the source of light, but in certain instances (electric starter, for instance) a short predetonation period, similar to that observed in tubes, was recorded.

On the whole, the results of these experiments complete those of P. Lafitte and confirm the theories of G. I. Taylor and J. B. Zeldovitch. From author's summary

266. Dawson, L. G., The fluid mechanics of detonation waves, *J. roy. aero. Soc.* **57,** 514, 618–626, Oct. 1953.

Author tries to give a simple one-dimensional analysis of the mechanics of detonation waves. Simplifying assumptions about the flow behind the detonation wave using the concept of a piston following the wave are used for the development of the equations. They are discussed with reference to investigations by G. Taylor.

The paper shows that simplified analysis of the problem is difficult without creating contradictions. That is borne out by the fact that, in a postscript, author has to admit that "in the paper it is unintentionally implied that ΔT might represent the change in total temperature across the detonation waves, although the analysis shows that that is not the case."

In general, the paper contains many interesting thoughts on one-dimensional analysis of supersonic flow.

H. J. Ramm, USA

267. Roy, M., On the structure of stationary flames, Fourth Symp. (International) on Combustion, 178–182, 1953; Baltimore, Md., Williams & Wilkins.

Structure of one-dimensional combustion waves has been investigated theoretically. Author considers heat conduction and viscosity, starting from conservation laws for momentum, energy, mass and neglecting diffusion effects. Introducing dimensionless variables, he obtains three differential equations for the functions $\chi(\xi)$ = dimensionless velocity; $\Delta(\xi)$ = dimensionless enthalpy; $\alpha(\xi)$ = fraction of heat of reaction, depending on the dimensionless coordinate ξ and with boundary conditions at infinity. For vanishing heat of reaction and Prandtl number = 3/4, temperature gradients are due to compression only, heat conduction and viscosity effects cancelling. Author derives, under simplifying assumptions for the general case (heat of reaction $\neq\sigma$), an expression for the burning speed depending on characteristic temperature, viscosity, and maximum rate of reaction. C. Franze, Germany

268. Barber, R., Jackson, R., Land, T., and Thurlow, G. G., A suction pyrometer for measuring gas exit temperatures from the combustion chambers of water-tube boilers, *J. Inst. Fuel* **27,** 163, 408–416, Aug. 1954.

The design of a suction pyrometer for measuring gas temperatures in large flue-gas ducts at temperatures below 2200 F is described and the use of the instrument is discussed with particular reference to the measurement of temperatures at the exit of the combustion chambers of water-tube boilers. The accuracy of the pyrometer is assessed, first, from theoretical considerations, and second, by two independent but indirect experimental methods. The results of these three methods agree and show that the accuracy of the instrument is good. Methods of correcting the observed readings are given. The second part of the report discusses the practical problems of using the instrument, and test procedures are given to insure reliable results. A note on the use of refractory heads to extend the temperature range of the instrument is appended. From authors' summary

269. Rössler, F., Optical investigation of the adiabatic combustion of solid fuels (in German), *Z. angew. Phys.* **6,** 4, 175–182, Apr. 1954.

Low resolution time-resolved spectra in emission and absorption have been obtained from the combustion products formed from nitroglycerin and nitrocellulose powders. A high-pressure mercury lamp served as light source for absorption measurements. The expected distribution of continuum radiation, discrete lines (belonging, e.g., to Na, K, Ca), and bands (belonging, e.g., to CaO, OH, NO, NH, CN), was observed; the continuum radiation

increased with pressure and originated presumably from solid carbon. Line spectra showed self-reversal resulting from the presence of cool gases in the vicinity of the observation windows.

Utilizing the results of an earlier study on the relation between particle concentration and (gray-body) emissivity, a convenient method is described for temperature measurement.

The maximum temperature is shown as a function of loading density for a black nitrocellulose powder. The observed peak temperatures during burning for moderate loading density (0.04 to 0.13 g/cm²) exceed the adiabatic flame temperature by about 600 K. Very intense radiation for short wave lengths is ascribed to chemiluminescent radiation. Temperature and particle concentrations as functions of time were determined also for a non-black French nitroglycerin powder.

In conclusion, some brief remarks are made concerning infrared radiation from flames and a two-color method for temperature determination.

Rössler's studies parallel extensive optical measurements on solid propellants carried out in this country during World War II. The experiments are done well and this work should not be overlooked by investigators interested in optical studies on powder flames. S. S. Penner, USA

270. Boedewadt, U. T., A rapid method for the determination of the theoretical performance of propergols (propellants) (in French), *ONERA NT* no. 15, 106 pp., 1953.

Tables are presented which permit a rapid iterative calculation of the performance of propellants (fuel and oxidant) containing C, H, and O at a combustion pressure of 16 kg/cm². The method is illustrated for the combustion of 76% ethyl alcohol-24% water in liquid oxygen. Flame temperature, molecular weight of the burned gas, specific consumption, and other properties related to rocket performance are calculated as a function of mixture ratio. The development of the method is described in detail.
M. Gerstein, USA

271. Wivstad, I., Spontaneous ignition of ash deposits (in Swedish), *Tekn. Tidskr.* **84, 24**, 557–560, June 1954.

Spontaneous ignition of deposits and air-heater fires have been experienced with all types of preheaters, especially in boiler plants using heavy residual fuel oils. To study the behavior of such deposits, the author describes a laboratory test, using an electrically heated muffle furnace, a 2-gram sample of deposit (analysis as an example: 51% C, 16.1% Fe, 2.3% V, 0.2% Na, 1.1% S (total), 0.9% S (as free H_2SO_4)), controls for a rate of heating of 200 C/hr, a temperature recorder for both the temperature of the sample placed in a dish of asbestos paper and of the furnace itself, and a gas analyzer. Two types of spontaneous ignition were found, a partial ignition at the surface causing a rapid increase of the sample temperature, or a slow oxidation starting inside of thick deposits. Slow oxidation occurs easier in fine-grained material. Above-mentioned sample resulted in a self-ignition temperature of 400 C, the fuel oil itself one of 245 C, blends of oil and deposit (and/or soot) stayed at 245 C down to 30% oil, demonstrating the danger of incomplete combustion in oil-fired furnaces. Spontaneous ignition tendency decreased with decreased oxygen content. As a consequence, deposits of unconsumed oil droplets should be avoided, and temperatures of air preheaters should be observed, also after shutdown, eventually coupled with automatic addition of CO_2 (from a battery of cylinders) to reduce the O_2 content of the atmosphere. W. Gumz, Germany

272. Sulzer, P. T., Influencing the oil-ash deposition in gas turbine plants by controlling the combustion (in German), *Schweiz. Arch.* **20, 2**, 33–41, Feb. 1954.

273. Sulzer, P. T., Fuel additives for avoiding oil-ash deposits in gas turbines (in German), *Schweiz. Bauztg.* **72, 7**, 79–82, Feb. 1954.

274. Mallory, B. C., and Allen, W. F., Jr., Air preheater size selection to improve over-all steam power-plant efficiency, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-62, 17 pp.

The cold end metal temperature of an air preheater to a boiler installation must be maintained at a high enough value to minimize corrosion and plugging of the air heater. This metal temperature is dependent on the temperature of the gas and air passing over it and, consequently, the minimum allowable flue-gas exit temperature to prevent corrosion is related to the air temperature to the preheater. Air by-pass, hot air recirculation, and steam reheating, using extraction steam from the turbine, are all possible means of raising the air temperature to the preheater, hence maintaining cold end metal temperature under conditions, such as at low load, where the gas exit temperatures are low. Studies are made of the possible improvements in over-all efficiency of 66 mw and 100 mw steam electric generating plants by selecting the optimum rotary air preheater size together with the best protective method for the "cold" end. It is shown that the use of steam heating may result in a two-fold gain, compared with supplying ambient air to the preheater: (1) An improvement in the thermal cycle due to the generation of additional by-product power, and (2) a decrease in dry-gas loss due to the lower permissible flue-gas exit temperature. The total possible gain with oil or high-sulphur coal firing may exceed 2%.
From authors' summary by G. G. Thurlow, England

Acoustics

(See also Revs. 38, 124, 137, 221)

275. Beranek, L. L., Acoustics, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, x + 481 pp. $9.

Scientific acoustics, having been preferentially a domain of physicists for many decades of its earlier stages, is developing a rapidly growing branch: the field of acoustical engineering. Modern industry is concerned with a great diversity of problems in this field and it is the acoustical engineer to which this book is addressed. Following a thorough outline of the fundamentals of acoustical physics, the general theory of mechanical and acoustical circuits is treated. Special emphasis is placed upon reducing acoustical problems as far as possible to equivalent problems of electrical-circuit theory. Among the subsequent topics, which are listed in detail below, extended attention is paid to problems of sound in enclosures, methods for noise reduction, hearing, speech, intelligibility, and psychoacoustic problems. The chapters on loud-speaker enclosures, horns, and rooms are of particular significance for high-fidelity sound reproduction. It is shown how the over-all system is to be designed in order to achieve a desired response.

A large number of figures contribute toward the understanding of the text, which does not require extended mathematical knowledge. Numerical examples as well as problems are attached to each chapter. Suggestions for the best use as a textbook are included. The author, well-known for his experience of many years in both practicing and teaching acoustical engineering, presents a stimulating and comprehensive study from which both students and engineers will draw valuable understanding and information on modern technical acoustics.

Contents: Introduction and terminology. The wave equation and solutions. Electro-mechano-acoustical circuits. Radiation of sound. Acoustic components. Microphones. Direct-radia-

tion loud-speakers. Loud-speaker enclosures. Horn loud-speakers. Sound in enclosures. Noise control. Acoustic measurements. Hearing, speech intelligibility, and psychoacoustic criteria. Problems. Appendix. F. E. Borgnis, USA

276. Helmholtz, H., Sensations of tone, New York, Dover Publications, Inc., 1954, xix + 576 pp. $4.95.

Book is an unabridged reissue of the English edition (which, in turn, was a translation of the German edition of 1887). This latest edition contains a new introduction and bibliography by Henry Margenau, Yale University. Ed.

277. Medwin, H., An acoustic streaming experiment in gases, *J. acoust. Soc. Amer.* **26,** 3, 332–341, May 1954.

The results of experiments with argon and dry nitrogen and moist air "indicate that: (1) the Navier-Stokes equation, the equation of continuity, and the acoustic 'equation of state' $P_1 = \rho_1 C_0^2 + \mathcal{R}\dot{\rho}_1$ provide a valid basis for second-order studies of streaming; (2) thermal conduction effects may be introduced into the Eckart streaming equations in the same manner as they appear in the attenuation formulas; (3) the macroscopic quantity, bulk viscosity, is made up of contributions from the intramolecular processes of vibrational and rotational relaxation." From author's summary by K. M. Siegel, USA

278. Satô, Y., Study on surface waves, X. Equivalency of *SH*-waves and sound waves in a liquid, *Bull. Earthq. Res. Inst. Tokyo Univ.* **32,** part 1, 7–16, Mar. 1954.

Since the displacement in *SH*-waves and the dilatation in sound waves in a liquid satisfy similar differential equations, there is correspondence of solutions in two types of problems. In the boundary conditions, the continuity of displacement in the first type of problem corresponds to the continuity of stress in the second, and vice versa. Thus, free surface in case of *SH*-waves plays a part similar to that of a rigid boundary of a liquid. W. S. Jardetzky, USA

279. Levine, H., Acoustic radiation pressure on a circular disk, Proc. Symp. appl. Math., vol. V, "Wave motion and vibration theory," New York, Toronto, London, McGraw-Hill Book Co., Inc., 63–69, 1954.

L. V. King's solution [*Proc. roy. Soc. Lond.* (*A*) **153,** 11–16, 1935] of the title problem for normal incidence of a plane, monochromatic wave is improved by a variational formulation, the details of which follow closely an earlier analysis of the scattering by a fixed disk [H. Levine and J. Schwinger, *Phys. Rev.* (2) **74,** 958–974, 1948]. King's results, applicable only at low frequencies, are extended to include approximations valid at high frequencies. J. W. Miles, USA

280. Barthel, R., Sound velocity in some aqueous solutions as a function of concentration and temperature, *J. acoust. Soc. Amer.* **26,** 2, 227–230, Mar. 1954.

Precision sound-velocity measurements are reported in sucrose solutions in the concentration range up to 3 molal, and in solutions of NaCl and $Pb(NO_3)_2$ up to a 2 molal. Measurements were made at three temperatures—24.76 C, 40.37 C, 59.60 C—using 15-Mc sound. For sucrose and NaCl, the velocity vs. molality relation is linear out to about 1 molal, where a slight decrease in slope sets in. For $Pb(NO_3)_2$, the velocity vs. molality relation has a negative slope, and a rise from linearity is already evident at 0.5 molal.

A simple theory of the concentration dependence of the sound velocity in solutions is developed and correlated with experimental data. From author's summary

281. Urick, R. J., The backscattering of sound from a harbor bottom, *J. acoust. Soc. Amer.* **26,** 2, 231–235, Mar. 1954.

When underwater sound strikes the bottom of the sea in shallow or deep water, a portion of its intensity is scattered back toward the source of sound. A study of the back-scattering from the bottom as a function of pulse length, frequency, and tilt angle at several locations in a harbor along the East Coast, was made by using a tiltable transducer mounted on a barge. The results are expressed in terms of a quantity called the "scattering strength" of a unit area of bottom.

The results suggest that the back-scattering of sound from a natural bottom is due more to its roughness than to the fact that it consists of sedimentary particles. Even at normal incidence the bottom of a sea or bay appears sufficiently rough so that little sound is returned by specular reflection. Some evidence in support of these conclusions is given. From author's summary

282. Ingard, U., Sound absorption by perforated porous tiles. I, *J. acoust. Soc. Amer.* **26,** 3, 289–293, May 1954.

Paper presents a theoretical analysis of acoustic properties of the perforated porous tile with rigid backing. Perforations are considered as ducts with absorbent side walls and terminations. Calculated and measured values of specific acoustic impedance versus frequency agree reasonably over a range of tiles with varying depths of perforation. J. P. Musgrave, England

283. Ingard, U., Perforated facing and sound absorption, *J. acoust. Soc. Amer.* **26,** 2, 151–154, Mar. 1954.

Author analyzes impedance of porous layer covered with perforated facing. He shows that an extra acoustic resistance appears in impedance when air space between porous material and facing is less than a perforation diameter. This is due to the region of distorted flow behind perforations being larger than the air space and invading the porous material. Theoretical curves of absorption coefficient versus frequency demonstrate the significance of the effect. J. P. Musgrave, England

284. West, F. L., A brief review of the problem of exhaust silencing, *Aero. Res. Counc. Lond. Rep. Mem.* 2803, 13 pp., May 1946, published 1954.

This note reviews past and present work on noise reduction of the reciprocating engine exhaust. Collected measurements of the noise level surrounding various engine installations and the effect of silencing experiments on engine and aircraft performance are presented. In view of the growing application of the gas turbine, some recent observations of its noise characteristics are included.

The adverse effects of simple baffle silencers on engine power illustrate the need for renewed investigation of silencing by acoustical interference methods allowing unrestricted gas flow. In this respect, limitations of past work on the theory of silencers are discussed and possible improvements suggested.

In conclusion, a tentative method of calculating the influence of engine and exhaust-pipe design on the noise spectrum is applied to a typical system. From author's summary

285. Darner, C. L., An anechoic tank for underwater sound measurements under high hydrostatic pressures, *J. acoust. Soc. Amer.* **26,** 2, 221–223, Mar. 1954.

The new USRL tank for making acoustic measurements under hydrostatic pressures up to1000 psig and controlled temperatures from near freezing to near boiling is described. The internal treatment of the tank with wedges of Insulkrete, a sound absorbing material composed of pine sawdust and Portland cement, is pictured. Oscillograms of the pulsed signal show the reduction

in reverberation level effected by Insulkrete. The conversion by Insulkrete of high-frequency sound energy into heat is illustrated by schlieren photographs. From author's summary

Ballistics, Detonics (Explosions)

286. **Newell, H. E., Jr., High altitude rocket research,** New York, Academic Press, Inc., 1953, xiv + 298 pp. $7.50.

Author, who is head of the Rocket-Sonde Research Branch, Naval Research Laboratory, Washington, D.C., gives a very clear and concise account of all the published high-altitude rocket-research work done during the past six or seven years. A wealth of information and numerous references are given about rocket experimental techniques and the results from more than 150 firings of captured German V-2 and USA-developed rockets, such as Aerobee, Viking, and WAC Corporal.

In general, the technical and physical problems are put in the foreground instead of the mathematical and theoretical aspects, but sufficient theoretical background is provided for any of the numerous problems treated. Results are compared with theory. The book is thus an excellent guide for both specialists and laymen into the physics of the high atmosphere as well as into the rather unknown field of high-altitude rocket-research techniques. It shows clearly all the difficulties of measuring various elements from a flying rocket that rolls, spins, and yaws and which is destroyed nearly completely after only 4 to 5 min of flight. It also is an appreciation of all the efforts and the skill of technicians and scientists taking part in the experiments.

Chap. 1: "The upper atmosphere as it appears today" gives details about rocket-research program and facilities. Chap. 2: "The rocket as a research vehicle," its performance and limitations, gives insight into the enormous difficulties of experimenting on flying rockets—with many months of preparation culminating in a few minutes of flight. Chap. 3: "Recovery of data" describes main telemetering systems used and possibilities of physical recovery of parts of equipment. Tracking of rockets and the problem of correlating position of rocket and atmospheric measurements are included. Chap. 4: "Pressures, densities, and temperatures in the upper atmosphere" and chap. 5: "Winds in the upper atmosphere" discuss the various possibilities of measuring ambient quantities from flying rocket, sources of error, and a summary of available data. Chap. 6: "Rocket measurements of solar radiation." On October 10th, 1946, the first solar spectrogram from above the ozonosphere was obtained, followed by many more, extending our knowledge of solar spectrum to below 2000 Å. Further, various techniques to measure solar radiation below 2000 Å to the soft x-ray region by, e.g., counters and photographic emulsions are described. Chap. 7: "Composition of the high atmosphere" outlines methods of measuring ozone distribution, diffusive separation in the high atmosphere. Chap. 8: "The ionosphere and the earth's magnetic field." Tracking of rocket by Doppler-effect method gave means to measure charge densities in the ionosphere. Magnetometers measured the total geomagnetic field and gave evidence of current sheets in the ionosphere, which may explain irregularities in the earth's surface field. Chap. 9: "Cosmic rays." Measurements in rockets have been carried out with practically all instrumentation earlier known—ionization chambers, counters, photographic emulsions, and cloud chambers. First results now available about composition of primary cosmic rays show predominance of heavy protons and alpha particles. Chap. 9: "High altitude photography" describes its techniques and aspects.

Book contains more than 200 references, 93 pictures and graphs, and 37 tables. H. Merbt, Sweden

287. **Darpas, J.-G., Influence of wind on a spinning artillery shell** (in French), *Mém. artill. fr.* **27,** 1, 139–170, 1953.

The influence of horizontal wind on the motion of a spinning shell is considered on the basis of the theory of R. H. Fowler and co-workers (1920). A frame moving with the wind is introduced in which the primary effect of the presence of wind upon the motion of the shell about its mass center is simply an increase of the initial yaw. This implies increased deceleration and change in side force. Due to both these factors, the trajectory under wind will differ from what it would be if computed on the basis of the simple mass point model. Formulas and numerical examples for this difference are given, which, however, is "always small except when the speed of the shell takes, along its trajectory, values of the order of magnitude of the wind speed." Besides the case of uniform wind, a sudden change of wind speed at some altitude is also considered. G. Kuerti, USA

288. **Crocco, G. A., From the dirigible to the missile** (in Italian), *Aerotecnica* **33,** 1, 6–9, Feb. 1953.

Author abridges the stability criterion for dirigibles and transfers it to the field of missile dynamics. For a missile with a tail unit but without wings, the equation for its rotational motion is identical to the equation of rotational motion of dirigibles, excepting for the metacentric height term. On the other hand, the equation of derived motion is identical in both cases.

The analysis of the equation of vertical pitching motion has the following consequences: (1) Statically stable missiles are dynamically unstable (case $h < 0$, h being aerodynamic coefficient). (2) Statically unstable missiles are dynamically unstable (case $h > 0$).

The analysis of the h coefficient, in case $h > 0$, permits finding the stability conditions for missiles which are formally similar to those dirigibles.

As the mass of missiles exceeds dynamically the aerodynamic forces, to insure stability it is necessary to employ an artificial stabilization that creates the fundamental factors of stability which are missing or insufficient. One free gyro and one rate gyro attain this purpose.

In this way author finds again the expression of the binomial correction $\phi\gamma + \Sigma\dot{\gamma}$, showing the possibility of applying to the ballistic problem some of the mathematical methods established for dirigibles at the beginning of the century.

J. A. Bulgheroni, Argentina

289. **Anonymous, Instrumentation of rockets and missiles,** *Instrum. and Autom.* **27,** 4, 606–607, Apr. 1954.

Soil Mechanics, Seepage

290. **Technical terms in English, French, German, Swedish, Portuguese and Spanish used in Soil Mechanics and Foundation Engineering,** Zürich, Inter. Soc. Soil Mech. Foundation Engng., 1954, 100 pp.

Book contains a list of 1200 terms with alphabetic cross reference in each of the five languages. These were compiled in connection with papers presented at the Third International Congress on Soil Mechanics and Foundation Engineering. Ed.

291. **Mogami, T., An approach to the system of soil mechanics,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 297–301.

From the principle of conservation of energy, work applied to a soil becomes heat or internal energy. Thus compaction of loose

soil of nonuniform porosity produces heat at first, then internal energy. A compression test produces internal energy at first, then heat as failure approaches. E. S. Barber, USA

292. Fountaine, E. R., Investigations into the mechanism of soil adhesion, *J. Soil Sci.* **5, 2, 251–263, July 1954.**

Investigations into the mechanism of the adhesion between soil and foreign surfaces in normal loading tests are described. The adhesion is found to be due entirely to the water film between the joined surfaces, and its magnitude is approximately equal to the moisture tension in this film multiplied by its area. The effects of the soil, the foreign material, and the testing technique on the tension in the moisture film are discussed.

From author's summary

293. Hansen, J. B., Calculation of earth pressures. New methods of investigation, *Dock Harb. Author.* **34,** 401, 335–340, Mar. 1954.

294. Janbu, N., Stability analysis of slopes with dimensionless parameters, *Harvard Soil Mech. Ser.* no. 46, 81 pp., Jan. 1954.

Paper presents an elaborate expansion of the "resistance-envelope" method of stability analysis of slopes proposed by A. Casagrande [AMR **4,** Rev. 4334]. The method makes use of systematically selected circular-cylindrical sliding surfaces. The resistance envelope is the locus of the largest required (average) shear stresses plotted against the (average) normal stresses for the various assumed sliding surfaces. Safety factors are derived by comparing ordinates of the envelope with corresponding shearing strength values for the given soil. Effects of uniform surcharge, partial submergence, drawdown, tension cracks, concentrated loads, and combinations thereof are investigated in detail. Variables of problems are expressed by dimensionless parameters, whenever it is possible. Various definitions of the safety factor used in stability analyses are critically discussed.

O. Hoffman, USA

295. Shestakov, V. M., Investigation of internal kinematics of unsteady seepage and derivation of equation of unsteady seepage (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **91,** 5, 1047–1050, Aug. 1953.

In derivation of Boussinesq equation for two-dimensional unsteady seepage with horizontal impervious bottom, an assumption is made that the horizontal components of velocity are constant in each vertical section, which leads to linear variation of the vertical components of velocity with depth.

Seeking experimental verification of these two propositions by using flow of glycerine in a thin vertical slot, author finds that they are both in error, but that the mean horizontal velocity in the cross section is nearly equal to the horizontal velocity at the surface. Using this experimental deduction instead of the constancy of horizontal velocities, author shows how it leads to the same Boussinesq equation, and how the latter can be generalized.

A. Hrennikoff, Canada

296. Kochina, N. N., Certain problems in spatial flow of underground water (in Russian), *Prikl. Mat. Mekh.* **17,** 3, 377–381, May/June 1953.

Paper outlines the solution of the three-dimensional problem of unsteady seepage resulting from sudden addition of water in the ground on top of the horizontal water table, over a certain area in plan, produced by rainfall or other cause. Explicit formulas and some graphs are given for special cases, including constant additional water head over rectangular and circular areas, and initial free surface in the form of sine waves. The depth of previous soil material is assumed either infinite or constant finite. The case of evaporation from the free surface is also referred to.

A. Hrennikoff, Canada

297. Mikasa, M., On the settlement of clay layer by partial load, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 303–308.

Derivations indicate that the initial excess pore pressure in a saturated elastic mass equals the added mean pressure. If total settlements are calculated from E and μ, initial shear settlements are calculated from $3E/2(1 + \mu)$ and $1/2$, respectively. In three-dimensional consolidation, the coefficient of volume decrease is $2(1 - \mu)$ times the one-dimensional coefficient.

E. S. Barber, USA

298. Goto, S., Measurements of the elastic modulus of clay by vibration experiments, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 291–295.

Author describes apparatus for determination of shearing modulus of elasticity and propagation velocity. He presents results of tests of three samples of clay with water content varying through plastic range. He shows that, for a given soil, both shearing modulus and propagation velocity are exponential functions of water content. H. H. Munger, USA

299. Lettau, H., Improved models of thermal diffusion in the soil, *Trans. Amer. geophys. Un.* **35,** 1, 121–132, Feb. 1954.

This paper should be of prime interest to geophysicists, climatologists, and to those interested in the micrometeorology of the surface layer of the atmosphere. A rigorous mathematical solution to the case of the semi-infinite solid with conductivity and capacity as functions of depth is presented. This represents a genuine advanee in soil heat-conduction work relating to the diurnal temperature oscillations. The work is supported by, and related to, experimental soil-temperature measurements.

F. C. Hooper, Canada

300. Sichardt, W., and Chardabellas, P., Surrounding of trench with methods of refrigeration (in German), *Bautechnik-Archiv* no. 9, 45–141, 1 plate, 1953.

For excavations in soil below the ground-water level, a process was introduced by Poetsch in 1883 and improved by Dehottay in 1930 which freezes the ground around the planned excavation. For this purpose, pipes are driven vertically in a distance of approximately 3 feet from each other into the ground forming a ring around the region to be excavated. Brine or a refrigerant is pumped through the pipes extracting heat from the surrounding soil and freezing it. The freezing process takes from one to four months. Excavation to a depth of 200 ft and pits to 1800 ft have been made in this way. Engineering calculations on the freezing process, of the strength and stresses in the frozen ground, and design and construction details are presented.

E. R. G. Eckert, USA

301. Meyerhof, G. G., Recent studies of foundation behaviour, *Engng. J., Montreal* **37, 2, 123–127, Feb. 1954.**

Article gives a summary of the conditions to be fulfilled in foundation design in relation to stability (based on plastic theory), to the amount of settlement (total and differential), to the rigidity of the soil and the superstructure, and to the eccentricity of the load.

In the appendix, author gives the relationship between the

density of sands, their penetration resistance, and the angle of internal friction. F. C. de Nie, Holland

302. Katel, I. E., Foundation of drop hammers, *Metal Treatm.* **21,** 103, 161–168, Apr. 1954.

The importance of guarding against the transmission of tremors in the foundations of drop hammers is discussed. Various designs and constructions of such foundations are described in detail.

From author's summary

Micromeritics

(See Rev. 155)

Geophysics, Meteorology, Oceanography

(See also Revs. 176, 207, 248, 281, 286, 293)

303. Rider, N. E., Eddy diffusion of momentum, water vapour, and heat near the ground, *Phil. Trans. roy. Soc. Lond.* (*A*) 246, 918, 481–501, June 1954.

Author presents results of an intensive observational study of turbulent transfer in the first 2m of air above a short grass surface. Direct measurements were made of the aerodynamic drag of the surface and of evaporation over a wide range of conditions of thermal stratification. A few heat fluxes were also evaluated less directly from heat-balance observations. Simultaneous detailed profiles of wind, humidity, and temperature enable the eddy diffusivities to be evaluated.

For adiabatic conditions the results conform closely with those from laboratory researches on turbulent flow over rough surfaces. No significant difference is found between the eddy diffusivities for momentum and water vapor in either adiabatic or nonadiabatic conditions. The evidence from the few values for the diffusivity for heat is less clear cut; on some occasions it is found to be much larger than the other two, but the differences are not systematic.

Reviewer considers this work to provide some high quality basic material on momentum and water-vapor transfer.

E. L. Deacon, Australia

304. Leight, W. G., Some possible applications of momentum-transport theory, *J. Meteor.* **11,** 1, 10–15, Feb. 1954.

The accumulation of relative angular momentum due to transport into zonal ring segments between selected longitudes is studied with the help of 5-day mean 700-mb charts. Latitudinal displacement and intensity tendencies for the maximum wind speed are defined on the basis of momentum-flux accumulation, and these tendencies are compared with contemporary and subsequent changes in position and intensity of the maximum zonal winds at 700 mb in the regions studied.

From author's summary

305. Kuo, H. L., On the production of mean zonal currents in the atmosphere by large disturbances, *Tellus* **5,** 4, 475–493, Nov. 1953.

The problem of the production of mean zonal currents by large-scale horizontal disturbances in the atmosphere is attacked by computation of time tendencies from the vorticity equation. It is shown that the earth's rotation, acting through the variable Coriolis parameter, generally produces a mean northward transport of westerly momentum, with the maximum transport occurring south of the middle of the zonal belt occupied by the disturbances, and therefore creating mean westerly and easterly currents in the central and outer parts, respectively. Its effect on the disturbance may be either a damping or an amplification, depending on the asymmetry of the mean flow profile.

Six different mean flow profiles have been investigated to determine the nature of the interaction between a disturbance and the mean zonal flow. For three profiles with inflection points, the interaction depends upon the wave length of the disturbance. If the wave length is longer than a critical value, an amplifying effect on the disturbance is produced, accompanied by a divergence of westerly momentum in the region of maximum mean flow; if shorter, a damping effect with a convergence of westerly momentum. On the other hand, the interaction produces only a damping effect for three mean flow profiles without inflection point.

Since the zonal currents in the atmosphere are seldom very strong and not far from symmetrical, the total effect of the earth's rotation and of the mean flow leads to horizontal damping, in which the contrast in the mean flow at different latitudes is increased and a mean northward transport of westerly momentum is produced. This is in qualitative agreement with observations, indicating that these factors are of real importance in the development and maintenance of the mean zonal flow.

From author's summary by W. W. Berning, USA

306. Raschke, K., A sturdy thermoelectric psychrometer for microclimatic measurements, *Proc. Indian Acad. Sci.* (*A*) **39,** 2, 98–107, Feb. 1954.

307. Bullard, E., The flow of heat through the floor of the Atlantic Ocean, *Proc. roy. Soc. Lond.* (*A*) **222,** 1150, 408–429, 4 plates, Mar. 1954.

The measurement of the temperature gradient and thermal conductivity in the sediments beneath the floor of the North Atlantic Ocean is described. Measurements were made at five stations. The mean heat flow and conductivity were found to be 0.98×10^{-6} cal/cm²s and 25×10^{-4} cal/cm °Cs. The heat flows at the individual stations range from 0.58 to 1.42×10^{-6} cal/cm²s. The high heat flow is an unexpected result, and it is difficult to find a source for so much heat. From author's summary

308. Vaughan, H. C., The spontaneous freezing temperatures of melted snow and of small water drops, *Bull. Amer. meteor. Soc.* **35,** 2, 52–55, Feb. 1954.

309. Magono, C., Short contribution on the shape of water drops falling in stagnant air, *J. Meteor.* **11,** 1, 77–79, Feb. 1954.

310. Kane, R. P., Practical methods of harmonic analysis for geophysical problems, *Proc. Indian Acad. Sci.* (*A*) **39,** 3, 117–126, Mar. 1954.

311. Grant, B. F., and Szasz, S. E., Development of an underground heat wave for oil recovery, *J. Petr. Technol.* 6, 5, 23–33, May 1954.

312. Kasahara, K., Experimental studies on the mechanism of generation of elastic waves, IV, *Bull. Earthq. Res. Inst. Tokyo Univ.* **32,** part 1, 67–77, Mar. 1954.

Although nominally a continuation of three previous reports [AMR **7,** Rev. 2094], part 4 is independent of parts 1–3.

Experiments are described in which an iron sphere containing an accelerometer was dropped onto level ground. Vertical surface displacements were measured at various distances from the point of impact. Consideration is given to the following phenomena: (a) The variation of amplitude and form of initial motion at a given point with height from which ball is dropped; (b) the

variation of amplitude and form of initial motion at a given point for a given height of drop when impact pads of different materials are used; (c) the motion of the weight during the process of impact and the conversion of its energy to that of elastic waves. This last topic is discussed in terms of a somewhat crude mechanical model. R. E. D. Bishop, England

Lubrication; Bearings; Wear

313. Lewicki, W., Hydrodynamic lubrication of roller bearings, *Engineer, Lond.* **197,** 5135, 920–922, June 1954.

Author first discusses the pressures developed in a fluid film between parallel rollers that are forced together. He shows that very high pressures are predicted by viscous film theory but contends that this does not imply film breakdown, as has been assumed by the other writers, but rather a distortion or flattening of the contact surfaces.

Assuming that the distortion consists of flats on each roller inclined to one another by a small angle and with relative motion toward one another, the author calculates the pressure distribution in the film and shows that it is very similar to the Hertzian distribution of contact pressure between elastic rollers. From this he concludes that the calculated pressure distribution is reasonably close to that actually existing in the film. Taking the pressure distribution in the film at a given load as the same as the Hertzian contact pressure distribution, he is able to calculate the minimum film thickness. This turns out to be independent of the load, the result being explained by the fact that increased load will widen the elastic impression and hence increase the resistance to outflow of the fluid.

An attempt is made to calculate the coefficient of rolling friction. These results do not appear to be correctly worked out, since the drag of the viscous film is not combined with the small component of the normal force produced by the inclination of the flats on the rollers. It is probable that the form of the expression for rolling friction is correct but the numerical coefficient is incorrect. W. O. Richmond, Canada

314. Bowden, F. P., The friction of non-metallic solids, *J. Inst. Petr.* **40,** 364, 89–103, Apr. 1954.

Paper contains a lecture delivered on the occasion of the award of the Redwood Medal to the author. It deals with unlubricated friction.

In the case of sliding metals, friction arises from the shear strength of metallic junctions. Some interlocking of the surface irregularities and the work required to plough out tracks in the softer material on the path of the surface summits of the harder metal cause an additional resistance against sliding. Friction is proportional to the real area of contact, which is small compared to the apparent touching area and does not depend on the magnitude of the latter, but upon the normal load. At the touching summits of the surface irregularities, plastic flow and with it formation of metallic junctions due to pressure welding, occur until the area of contact will have grown to such size that the pressures at the contacting points no longer exceed the yield-pressure of the materials. The real area of contact and with it the friction force are therefore proportional to the normal load and do not depend on the apparent touching area. Because of this the coefficient of friction is a constant depending only on the materials of the sliders. Presence of surface layers of oxide or absorbed gas reduces the extent of the welded junctions and with it the friction. Because of work-hardening of the contact region, shearing occurs a little distance beyond. Metal fragments are detached from one of the surfaces and wear appears.

That pressure welding takes place is demonstrated by observations of metallic transfer between metals in contact.

The mechanism of friction between nonmetals is very similar to that between metals, even in the case of brittle solids. Although the friction of brittle materials is accompanied by some cracking and surface fragmentation, their sliding behavior is also dominated by plastic deformation of the surface irregularities, because these materials cease to be brittle and can undergo marked plastic deformation without producing fracture, if they are exposed to high pressure. Therefore, also in this case friction is chiefly caused by strong interfacial adhesion. If the specimens consist of materials with great elasticity, the deformation of the contact regions is purely elastic if small loads W are applied. In this case, therefore, the real area of contact, and with it the friction, is proportional to $W^{2/3}$, and the friction coefficient increases with decreasing loads. For increasing loads, plastic deformation occurs again preponderantly and the friction coefficient becomes independent of load.

With certain solids the interfacial adhesion is low and therefore an abnormally low friction results. This is true for polytetrafluoroethylene. Also the friction on ice not too far from the melting point can be very low. Whereas the static friction on ice is high, the sliding friction decreases very much with increasing sliding velocities. This is due to the heat developed by friction, because it produces a melting and with this a lubrication of the sliding surfaces. In the neighborhood of 0 °C, pressure melting also can occur. Well below the melting point, the friction on ice is similar to that between metals and other solids. Krypton demonstrates a sliding behavior which corresponds to that of ice. U. Rost, Germany

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